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SUPPLEMENT
To All Former
TREATISES
ON THE

Use of the GLOBES,

Render'd Necessary

From the late IMPROVEMENTS

Exhibited to the Public on

Mr. NEALE's PATENT GLOBES.

In TWO PARTS.

PART I.

INTRODUCTORY: Containing the Description and Use of the several Circles and Points on the Globes, intended for the Instruction and Benefit of young Beginners.

PART II.

SUPPLEMENTAL: Wherein the superior Excellency and Utility of these Globes are ex-

emplified, in the Solution of above one hundred curious Problems in those noble Sciences, *Astronomy, Geography, and Navigation*; in so plain and intelligible a Manner, that such, who were before Strangers to the Nature and Cause of the Phenomena resulting from the Motions of the Heavenly Bodies, may with great Ease obtain a competent Knowledge thereof.

*Let Thought awaken'd take the Lightning's Wing,
And glance from East to West, from Pole to Pole;
Who sees, but is Confounded, or Convince'd?
Renounces Reason, or a GOD adores?*

YOUNG'S NIGHT THOUGHTS.

By **EDWARD MOORE**, Teacher of Geography and Navigation,
in Deptford.

L O N D O N:

Printed: And sold by *M. Cooper*, in *Pater-noster-Row*; *B. Cole*,
Mathematical Instrument Maker, in *Fleet-Street*, and by the
Patentee, at his House in *Leadenhall-Street*. M.DCC.LI.

4

SUPPLEMENT

TO THE

TRADE

USE OF THE GLOBES

FOR THE IMPROVEMENTS

MR. W. L. E.'S PATENT GLOBES

THESE GLOBES ARE THE ONLY
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TABLE

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TO HIS

Royal Highness

GEORGE,

Prince of Wales

This Treatise
is most humbly

Inscribed.

77



P R E F A C E.



AFTER so many curious Treatises on this Subject, the World may be induced to think any farther Attempt of this Kind altogether superfluous; and indeed, had not Mr. NEALE's late Improvements on the Globes rendered a Supplement absolutely necessary, I should have been intirely at a Loss to justify myself on this Account to the Publick; but, as this happens to be the Case, I presume any further Apology in Regard to this Publication will be deemed needless; I shall therefore (to avoid Prolixity) only beg Leave to add a Word or two with respect to the Work itself, after observing that,

“ Knowledge (as Mr. Locke hath said in his
 “ Preface to Human Understanding) had cer-
 “ tainly been much more advanced in the World,
 “ if the Endeavours of ingenious and indus-
 “ trious Men had not been cumbered with
 “ the learned, but frivolous Use of uncouth,
 “ affected, or unintelligible Terms, introduced
 “ into the Sciences, and there made an Art

The P R E F A C E.

“ of to that Degree, that Philosophy, which
“ is nothing but the true Knowledge of
“ Things, was thought unfit, or incapable
“ to be brought into well-bred Company,
“ and polite Conversation, and this from in-
“ significant Forms of Speech, and Abuse of
“ Language, which has so long past for the
“ Mysteries of Science; and hard and mis-
“ applied Words, with little or no Meaning,
“ have, by Prescription, such Right to be
“ mistaken for deep Learning, and Height
“ of Speculation, that it will not be easy to
“ persuade either those who speak, or those
“ who hear them, that they are the Covers
“ of Ignorance, and Hindrance of true Know-
“ ledge.” Persuaded of the Truth of this Asser-
tion, I have endeavoured throughout the Whole
(as best suiting the Design) to be as plain, easy,
and concise as possible, adapting the Subject to
the meanest Capacities, so as to render it
intelligible and attainable without the Help or
Assistance of a Master in Science.

And whereas my Business and Distance
from London would not permit me to give
so close an Attendance upon the Press, as I
could

THE PREFACE.

could have wish'd, and of course some Errors through Hurry or Inadvertency may have slipt into the Copy, the Reader is therefore desired candidly to correct whatever he may find amiss, more than what is already taken Notice of in the Errata annexed.

I shall now conclude, after barely mentioning, that, as in the first Part of this Treatise I have given a Table of the Latitude and Longitude, &c. of the Constellations from Mr. Martin, which I thought might be acceptable to some, so for the sake of others of my Readers, I judged that those trifling Explanations thereto added might not be unnecessary: This I have thought proper to take Notice of here, that if any thing therein be deserving of Censure, it may be applied where and to whom it properly belongs.

Errors

Errors Corrected.

Page 3, l. 13, for verticle read vertical.

Page 4, l. 20, read towards the sun (which remains fixed).

Page 7, l. 22, for points, read parts.

Page 27, l. 22, under the column water for terminates read terminated.

Ib. l. 14. for is communicated read communicates.

Page 30, l. 22, for compliment read complement.

Page 39, after lynx put the sign Π before $28^{\circ} 24'$.

Page 49, l. 1 and 3, for anchronically read achronically.

In the appendix, prob. VII. for earth's orbit, read moon's orbit.

In the Note, Page 67, relating to the Annual Circle, the Reader is desired to take notice that whereas Complaints were made of its being too small to admit of the Divisions of 365 Days being conspicuous, its Diameter is now so far enlarged as to circumscribe the whole Globe, by which Means the Pointer from the Sun becomes its proper Index,* which Contrivance affords a very pretty Illustration of the Phenomenon of the Sun, remaining in the same Place, and yet appearing to pass through all the Signs of the Zodiac in one Year.

A

* For the reasons aforesaid this pointer is to be regarded as the annual index so frequently mentioned in the prosecution of the work.

A TABLE of the LATITUDE and LONGITUDE of some of the principal Places of the Earth, most of them determined by astronomical Observations; *London* being accounted the first Meridian.

Places Names.	Latit.	Longit.
	0	0
Achin in Sumatra	5 16	95 53
Agra in Mogul's Empire	26 35	76 40
Aleppo in Syria	36 30	37 50
Alexandria in Egypt	31 11	30 25
Amsterdam	52 22	5 5
Archangel	64 36	40 5
Astracan	46 20	49 55
Bagdad	33 15	45 40
Berlin	52 28	13 44
Bombay	19 34	73 15
Brussels	50 49	4 29
Buda in Hungary	47 32	19 20
Cadiz	36 33	5 43
Cairo in Egypt	30 2	31 40
Canton in China	23 11	112 54
Cape of Good-Hope (according to Kolben)	34 15	21 25
Cape de Verde	14 43	17 05
Constantinople	41 00	28 40
Copenhagen	55 40	12 56
Dublin	53 14	6 20W
Dunkirk	51 01	2 26
Edinburgh	55 56	2 55W
Florence	43 42	11 47
Geneva	46 17	6 19
Genoa	44 25	8 40
Goa in the East-Indies	15 48	73 30
Hanover	52 23	10 6
St. Helena	16 00	5 50
Jerusalem	31 50	35 34
Ispahan	32 26	52 55

Leghorn

A TABLE of LATITUDE, &c.

Places Names.	Latit.	Longit.
Leghorn	43 30	10 30
London	51 32	0 00
Madrid	40 27	3 40W
Moscow	55 42	38 45
Naples	40 45	14 58
Paris	48 51	2 25
Peking	39 55	116 25
Petersburg	60 00	31 34
Prague	50 5	14 40
Rome	44 50	12 55
Siam in East-India	14 00	101 5
Stockholm	59 23	18 30
Toledo	39 51	3 28W
Toulon	43 06	6 01
Turin	44 50	7 44
Venice	45 35	12 45
Vienna	48 15	16 53
Warsaw	52 14	21 37
York	54 00	1 00W

N. B. The Latitude is North and the Longitude East if not otherwise expressed.

THE CONTENTS.

PART I.

SECT. I.

Of the great Circles of the Sphere, &c.

	Page
Introduction	1
Of the Horizon	3
Of the Meridian	6
Equator	7
Ecliptic	ib.
Colures	11

SECT. II.

Of the lesser Circles of the Sphere.

Of the Tropicks	12
Polar Circles	14

SECT. III.

Of the several Points on the Globe, &c.

Of the Poles of the Earth	15
Zenith and Nadir	ib.
Poles of the Ecliptic	ib.
Cardinal Points	16
Solstitial Points	ib.
Meridian, what	ib.
Longitude, what	17
A Table of decreasing Longitude	18
Latitude, what	20

SECT.

The CONTENTS.

SECT. IV.

Of the Division of the Earth into Climates and Zones.

A Climate, what	Page 21
A Table of Climates and Parallels	22
Its Use	24
A Zone, what	ib.
Of the Frigid Zone	ib.
Temperate Zones	25
Torrid Zone	ib.

SECT. V.

Of the Division of the Earth into Land and Water.

A Continent, what	26
An Island	ib.
An Ocean	ib.
A Lake	ib.
A Promontory	27
A Peninsula	ib.
An Isthmus	ib.
A Bay	ib.
A Gulph	ib.
A Streight	ib.

SECT. VI.

Of the Amphiscii, Periscii, Heteroscii, Antæci, Perizæci and Antipodes.

Of the Amphiscii	28
Periscii	29
Heteroscii	ib.
Antæci	ib.
Perizæci	30
Antipodes	31

SECT.

The CONTENTS.

SECT. VII.

Of the various Positions of the Globe or Sphere.

A direct Sphere, what	Page 32
Parallel Sphere	ib.
Oblique Sphere	34

SECT. VIII.

Of the Celestial Globe.

A Table of the Constellations	37
-------------------------------	----

SECT. IX.

Containing some necessary Definitions.

Declination of the Sun, or a Star, what	44
Latitude	45
Longitude	ib.
Altitude	ib.
Depression	46
Amplitude	ib.
Azimuth	ib.
Right Ascension	47
Oblique Ascension	48
Oblique Descension	ib.
Ascensional Difference	ib.
A Star Vertical, when	ib.
A Star rises and sets Cosmically, when	ib.
Achronically	49
Helically	ib.

SECT. X.

A more particular Description of Mr. Neale's new Method of mounting his Patent Globes — 50

PART.

The CONTENTS

PART II.

SECT. I.

Problems on the Terrestrial Globe.

To be work'd according to these Improvements.

PROB.

1. To find the Latitude and Longitude of any given Place ————— Page 61
2. The Longitude and Latitude of any Place being given, to find that Place on the Globe — 62
3. To find the Distance of any two Places on the Globe, in English Miles ————— ib.
4. To rectify the Globe according to the Latitude of any given Place ————— 64
5. To find the Sun's Place in the Ecliptic — 67
6. A Place being given, to find all those Places which have the same Hour with the given Place 69
7. The Hour of the Day being given in the Place where you are, to find what Hour of the Day it is at any other Place ————— ib.
8. A Place being given, to find all those Places on the Globe, which have their Days and Nights of the same Length ————— 70
9. The Day of the Month being given, to find those Places on the Torrid Zone, to which the Sun will be Vertical on the given Day ————— 71
10. The Hour of the Day being given in any Place where you are, to find the particular Place in the Torrid Zone, to which the Sun is at that Time Vertical ————— ib.
11. A Place being given in the Torrid Zone, to find those Days on which the Sun will be Vertical thereto ————— 72
12. Suppose it to be Noon-day in any given Place in the East or West-Indies, how to find the True Time of the Day at that Instant in London thereby ————— 73

The CONTENTS.

13. The Day and Hour of the Day being given, to find all those Places of the Earth that are within the enlightened Hemisphere— Page 74
14. The Day and Hour being given, to find all those Countries on the Globe, to which the Sun is then rising and setting — 75
15. The Day and Hour being given, to find all those Places on the Globe, where it is at that Instant Noon, and those to which it is then Midnight — ib.
16. A Place being given in one of the Frigid Zones, to find when the Sun begins his Departure therefrom, or to set without rising — 76
17. A Place being given in the Frigid Zone, to find on what Day the Sun begins to shine thereon without setting — 77
18. A Place being given in the Frigid Zone, to find how many Days the Sun shines upon it without setting, and how long he is totally absent therefrom — ib.
19. To find the Length of the longest and shortest Day to any Country on the Globe — 79
20. The Place and Day being given, to find at what Hour the Sun rises and sets, and the Length of the Day and Night — 80
21. How to find those Countries within the Temperate Zone, that have the greatest Degree of Twilight 81
22. To find the Length or Continuance of the Morning and Evening Twilight, in any given Place 82
23. How to shew the Time when the Moon rises and sets for every Day in the Year, to any given Place 83
24. To demonstrate how much the Moon rises and sets before or after the Sun every Day in the Year, in any given Place — 84
25. The Cause of an Eclipse of the Sun, how to demonstrate it — 85
26. To demonstrate the Cause of an Eclipse of the Moon — 86
27. To explain the Reason why they happen no oftner — ib.
28. How to exhibit a natural Representation of the Motion of the Moon's Nodes — 17
29. How

The CONTENTS.

25. How to demonstrate the aforesaid Motion of the
Nodes to be retrograde, or contrary to the
Order of the Signs — Page 88
26. How to demonstrate what Number of Years the
Moon's Nodes require, before they make one
compleat retrograde Revolution — 89
27. How to demonstrate the Reason why, notwith-
standing the Moon moves round the Earth in a
little more than 27 Days, it is full 29½ Days
before it gets from one Conjunction with the
Sun to another — — — — — *ib.*
28. To represent the several Phases of the Moon, and
shew the true Cause of that Variation — 90
29. How to exhibit a Representation of the Moon's
Motion once round on its own Axis, while it is
going once round the Earth — — — — — 91
30. The Day and Hour of the Day being given, when
a Solar Eclipse will happen, to find all those
Places on the Globe, to which the same will be
visible — — — — — 92
31. The Day and Hour of the Day being given, when
a Lunar Eclipse will happen, to find all those
Places on the Globe, to which the same will
be visible — — — — — *ib.*
32. To explain the true Cause of the Moon's rising
and setting every Day at such a Distance of
Time from the preceding one — — — — — 93
33. To exhibit the Nature of the Harvest Moon,
shewing the true Cause why the Moon then
rises several Days together within a small Space
of Time of what she did on the preceding
Day, contrary to what she does at any other
Time of the Year — — — — — 94
34. How to demonstrate that the Moon is nearer
to the Sun, by near half a Million of Miles,
when she appears as a new Moon, than she is
when she appears as a full Moon, allowing the
Orbit to be at 240,000 Miles from the Earth's
Centre — — — — — 96
35. How to shew the Sun's Amplitude for any given
Day of the Month — — — — — *ib.*
36. How

The CONTENTS.

40. How to demonstrate that the Inhabitants under the Equinoctial Line enjoy two Summers and two Winters every Year — Page 97
41. How to demonstrate that the Moon can never appear as a full Moon, during the Summer half-Year, to the Inhabitants of the North Pole 98
42. How to demonstrate that the Moon cannot be seen as a new Moon, during the Winter half-Year, to the said Inhabitants — 99
43. How to represent the Countries to which the Sun rises and sets within the Compass of the same Hour at certain Seasons — *ib.*
44. How to demonstrate that to certain Inhabitants of our Globe, the Sun will set near half a Year together within a Trifle of the same Hour of Time, but in the Interim differ above 20 Degrees with Respect to its Amplitude — 100
45. How to find the Sun's Altitude for any given Day throughout the Year, in any given Place *ib.*
46. How to find his Meridian Altitude on any given Day — — — *ib.*
47. How to determine the variation of the Needle by a Globe thus mounted on any Part of the Sea by one Observation only, suppose the Latitude known — — — 102
48. How to shew the Sun's Azimuth at any given Time by the Globe — — — 103
49. How to find the Hour of the Day by the Sun's Azimuth — — — *ib.*
50. How to find the Sun's Altitude by his Azimuth — — — 104
51. How to find the Time of the Day by the Sun's Altitude — — — *ib.*
52. How to find the Sun's Depression below the Horizon, at any given Time of the Night 105
53. How

The CONTENTS.

53. How to shew those Countries to which the Sun appears to them either rising or setting within a few Minutes of the same Time for several Days together, at a certain Time of the Year Page 105
54. How to demonstrate that to the People of a certain Latitude the Sun goes apparently backwards and forwards with regard to the Azimuth, twice in one Day, at a certain Season of the Year, without derogating from the miraculous going back of the Shadow mentioned in the Sacred Writings. 106
55. How to demonstrate that to the aforesaid Inhabitants there is a certain Day in the Year to which the Sun is almost the whole 24 Hours absent from them, and in the few remaining Minutes, only makes his Appearance just on a Level with the Horizon, and then sinks again as before 107
56. How to shew the Sun's right Ascension for any Day in the Year 108
57. How to shew the Sun's Declination ib.
58. The Day of the Month and Time of the Day known, how to find by the Globe the Latitude of the Place by the Sun's Meridian Altitude 109
59. The Day of the Month and Time of the Day known, how to find by the Globe the Latitude of the Place, by the Sun's Azimuth, any Hour of the Day 110
60. How to find the Latitude of the Place, by the Time of the Sun's rising in the Morning - *ib.*
61. How to find the Latitude of the Place, by the Sun's setting, on any Day of the Year 111
62. How to find the Latitude of the Place by the Sun's Amplitude. 122
63. How to find the Time of the Morning or Evening, by the Sun's Amplitude, at his rising or setting ib.
64. How to find the Day of the Month on the Globe by the Sun's Meridian Altitude 113
65. How

The CONTENTS.

- 65. How to find the Day of the Month by the Amplitude at rising or setting — Page 113
- 66. The Day of the Month and Time of the Day given, to find by the Globe how many Degrees and Minutes a Line drawn from the Zenith of a given Place, cutting the Centre of the Sun, will fall on the Horizon from the Meridian of the said Place — *ib.*
- 67. The Day of the Month given, how to find the Difference of the Distance at the Horizon of two Lines drawn from the Zenith of a given Place through the Sun's Centre while on the Meridian, and at one Hour's Distance of Time from his passing the Meridian, compared with two other Lines drawn, one an Hour before the Sun sets, and the other at the Time of his setting — 115
- 68. How to shew the Difference of the aforesaid Distances between the Equinoctial and the Horizon of the said Place — 116
- 69. To demonstrate how the Differences of the aforesaid Distances vary according to the Time of the Year — *ib.*

S E C T. II.

Problems on the Celestial Globe relating to the Sun and Moon.

PROB.

- 1. To rectify the Globe for any given Place 117
- 2. To find the Sun's Place in the Ecliptic — 118
- 3. To rectify the Sun and Moon over the Globe according to these Improvements, so that they shall correspond with their like Places in the Heavens — 119
- 4. To find the Time of the Sun's rising and setting for every Day in the Year. — 119

The CONTENTS.

5. To find the Time of the Moon's rising or setting
for every Day in the Year _____ Page 120
6. To shew the Number of Hours the Sun or Moon
appears above the Horizon on any Day of the
Year _____ 121
7. To shew the Number of Degrees the said Lumi-
naries descend below the Horizon at Midnight,
for any Day in the Year _____ *ib.*
8. To shew the Time when the Moon rises and sets
to any particular Latitude for any Day in the
Year _____ 122
9. To demonstrate how much the Moon rises and
sets before or after the Sun every Day in the
Year, to any given Latitude _____ 123
10. The Cause of an Eclipse of the Sun or Moon,
how to demonstrate it _____ *ib.*
11. To demonstrate that the Moon is more than two
Days longer in going from the Sun to her
Conjunction or Arrival at the said Luminary
again, than she is in making one compleat
Revolution round our Earth _____ 124
12. To shew the Nature of the Harvest Moon *ib.*
13. To demonstrate that to the People of certain La-
titudes, the Moon may be seen in their Hori-
zon either rising or setting within one Hour
of the same Time for every Day in the Year 125
14. To demonstrate that to the Inhabitants of *London*
the Moon may rise at a certain Time of the
Year 16 Hours before the Sun, and in the
Evening of the same Day the Sun will set no
more than 8 Hours before the Moon — *ib.*
15. To demonstrate that to certain Latitudes the
Moon may rise and set 15 Days together with-
in a Trifle of the same Time, yet vary in her
Amplitude near one Half of the Compass 126
16. To demonstrate that to the People of a certain
Latitude, it is either Morning or Evening with-
in one Hour of the same Time every Day
throughout the whole Year _____ 127

The CONTENTS.

17. To demonstrate that to the Inhabitants of the
aforesaid Latitude, at a certain Time of the
Year, it is both Morning and Evening with-
in the Compass of the same Hour. *Page* 128
18. To demonstrate that to the aforesaid Inhabitants,
there may be at a certain Time of the Year near
24 Hours between Morning and Evening *ib.*
19. To demonstrate that notwithstanding it may be
either Morning or Evening within one Hour
of the same Time to the Inhabitants of some
Parts of the Globe, yet there are certain others
to whom there is no less than 12 Hours diffe-
rence between the Sun's rising and setting
throughout the Year. ——— 129
20. To discover that particular Latitude to which the
Moon will have a larger Extent of Amplitude,
than to any other whatsoever. ——— 130
21. How to shew those particular Countries to which
the Moon, no less than twice in every Revolu-
tion round the Earth, appears to describe a
Ring round their Horizon. ——— 131
22. How to shew the Sun and the new Moon in Con-
junction at a certain Hour, each going round
the Horizon, when the Moon will be seen run-
ning through all the Points of the Compass so
much faster than the Sun, that at its Arrival at
the End of her Course the Sun will be no less
than 13 Degrees distance from her. ——— 131
23. To shew by the Interposition of the Moon's Body,
the Occultation of any fix'd Star in the Zo-
diac. ——— 132
24. To find by the Globe the Time of high Water at
London-Bridge, on any given Day of the Moon's
Age. ——— 133
25. To demonstrate the Reason of the ebbing and
flowing of the Tides, at such Distance of Time
from one Day to another. ——— 133
26. How to find the Time of the Night by the Alti-
tude of the Moon. ——— 134
27. To Shew the Time of the Night by the Sun's
Azimuth. ——— 135

* In the foregoing Prob. 16, instead of every Day through-
out the whole Year, read, for several days together at cer-
tain Seasons of the Year.

The CONTENTS.

28. To shew by the Globe the Time of the Night by the Moon's rising ————— 136
29. How to demonstrate that the Moon moves slower than the Earth in her annual Orbit, from the Beginning of the last to the End of the first Quarter ————— Page 137
30. How to demonstrate that from the End of the first Quarter, to the Beginning of the last, the Moon moves faster than the Earth in her Yearly Course ————— ib.
31. To demonstrate that, if the Earth was in a State of Rest, the Moon would appear to an Eye from the Sun to move retrograde one half of her Course round the Earth, or 15 Days out of every Month ————— 139
32. The Reason why the Moon can never be seen at the North pole, during the Summer half Year, as a full Moon; or as a new Moon during the Winter half Year ————— 139
33. The Reason why the Moon shines without setting from the first to the last Quarter, to the said Inhabitants, during the Sun's Absence — 140

S E C T. III.

Problems with their Solutions relating to the inferior Planets, *Mercury* and *Venus*.

- PROB.**
1. How to exhibit their several Phases according to their different Stations in their Revolutions round the Sun; as they are seen through a Telescope ————— 141
2. How to demonstrate the Reason why *Venus* in certain Stations may rise to the Inhabitants of *London* within about an Hour of the same Time with the Sun in the Morning, and in the Evening of the same Day six Hours after the Sun ————— 142
3. To demonstrate that to a certain Latitude the Sun and *Venus* may both rise at the same Time in the Morning, and in the Evening of the same Day, *Venus* may set six Hours before the Sun; ————— 143

The CONTENTS.

4. To demonstrate, that to a certain Latitude, the Sun, Moon, Mercury, and Venus, may be all rising on a particular Day together in the Morning; yet on the same Day may observe the Moon to set 12 Hours before the Sun; Mercury 14 Hours after the Moon, and Venus 6 Hours after all three — Page 144
5. How to shew the Difference of the respective Amplitudes in the aforesaid Stations at the Time of rising — 145
6. To discover the Height of the Diurnal Arc of each of the Luminaries and Planets aforesaid, on any given Day, above the Horizon — 146
7. To demonstrate the Reason why neither Mercury nor Venus can be seen on the Meridian of London at Midnight, as all the other Planets at certain Times are — 147
8. To demonstrate, that to certain Places on the Globe, Venus may be seen at particular Times on the Meridian at Midnight, or at the same Time the Sun is on the said Meridian, but below the Horizon — ib.
9. To represent both Mercury and Venus sometimes appearing like black Spots in the Sun's Disk, and at other times as lost behind it — 148
10. To shew the two Planets aforesaid, as they appear in the Heavens, representing sometimes Morning, and at other times Evening Stars — 149

S E C T. IV.

Problems on the Celestial Globe, with their Solutions, relating to the fixed Stars.

PROB.

1. To find the Latitude and Longitude of any given Star — 150
2. The Latitude and Longitude of any Star being given, to find the same on the Globe — 151
3. To find the right Ascension of any fixed Star ib.
4. To

The CONTENTS.

4. To find the Declination of any fixed Star on the
Globe. ————— Page 152
5. To find the Distance of any two Stars in Degrees
and Minutes. ————— 153
6. A Star being given, to find all those Stars which
have the same Degree of Latitude with the
given Star. ————— 154
7. A Star being given, to find all those Stars on the
Globe, which have the same Degree of Lon-
gitude. ————— *ib.*
8. To find what particular Stars make one continual
Round above the Horizon of a given Latitude,
and never set below it. ————— 155
9. The Latitude given, to find all those Stars on
the Globe which are never seen to the Inha-
bitants thereof. ————— *ib.*
10. The Place and Day given, how to represent the
Face and Appearance of the Heavens, and shew
all the fixed Stars above the Horizon, for any
particular Hour of the same Day. — 156
11. How to find the Time of any given Star's Rising,
Setting, or coming to the Meridian. — 157
12. The Time of the Day or Night given, how to
find by the Globe what Height any particular
Star is above the Horizon, and what Situation
it is, with respect to the Point of the Compass,
by which it may be readily found. — 158

OF

USES *of* GLOBES.

NOTHING gives a more clear and speedy idea of the earth and visible heavens, than the globes; the most natural image, and representation of them, being from thence open to our view; nor can any thing contribute more to facilitate the improvement of an inquiring mind in the delightful knowledge thereof, Especially in the method they are hereafter proposed to be mounted; a method very different from all hitherto exhibited; whereby the sun at a small distance from the terrestrial globe is represented as a fixed body, and the moon as moving round the globe in 29 days and a half, in that space which is between the earth and it: but on the celestial one 'tis otherwise; for in order to shew the apparent motion of these luminaries by this globe, the sun as

B

well

well as moon is represented as rising and setting every day.

But before we begin to speak particularly of this method, in point of preference to all others, it will be necessary, for the sake of those entirely unacquainted with any treatises on this subject, or are ignorant of the artificial globes, or their uses, just to give a general description of the points and circles that are found thereon.

The most remarkable circles on the globe are in number ten; six being called great circles, and the other four lesser circles.

The six greater circles of the sphere are the horizon, the meridian, the equator, the ecliptic, and the two colures; dividing the globe into two equal parts: the four lesser circles are the two tropics, and the two polar circles; and these divide the sphere into unequal portions.

The points of greatest moment are the zenith and nadir, the arctic or north pole, the antartic or south pole, the



the north and south points in the intersections of the meridian with the horizon, and the east and west in the same circle, together with the equinoctial and solstitial points.

Of these briefly in their order.

I. The horizon, in common globes, is the flat part cover'd with paper, on a wooden frame in which the globe stands: on the celestial globe of this new improvement 'tis the same, but on the terrestrial 'tis different, being the great verticle circle fix'd on the pedestal, and in which the globe is hung, in such manner as to turn, and represent its annual motion, by the pole of the equator making one revolution round the pole of the ecliptic in 365 rotations, on its own axis; however, in either method, the horizon divides the globes into two hemispheres, determining the rising and setting of the sun, and distinguishing day from night.

According to the old method, when
the

the sun is in the east part of the horizon, 'tis rising; when in the west, 'tis setting; when above the horizon, 'tis day; when below, 'tis night; this also will hold good in the new method, as to the celestial globe; for by turning it about, the sun and moon will rise above the horizon in the east, and set below it in the west, moving over the globe, whilst the globe itself is revolving, just in the same proportionable degree as they do in the heavens: But on the terrestrial globe, by turning to any particular country thereon, and observing when it arrives within the enlighten'd hemisphere, you will find it just rising above the vertical horizon, and by continuing the rotation, all the time while it is coming towards the (sun which remains fix'd) a line drawn from that country to the sun, will point eastwards, when it arrives opposite to the sun it will point directly south, but when it has past the sun, all the time it is in its progress

progress towards the opposite point of the horizon, the line will then point more and more towards the west, so as to lose sight of the sun, when arrived at the extremity of the horizon, but yet not so as to be deprived of all benefit of its light, because till that particular country has roll'd about 18 degrees beyond or below the horizon, the sun's rays entering the atmosphere, the light is thereby reflected in such a portion or degree as to make what is usually called Twilight.

This great circle of the horizon is distinguished into the sensible and the rational.

The sensible horizon supposes the spectator placed on the surface of the earth or water, and reaches no farther than the eye can see; but the rational, or true horizon, is that which divides the globe into two halves, and supposes the spectator placed in the centre of the earth.

II. The

II. The meridian, in the common method of mounting, is a great brazen circle in which the globe moves; it crosses the horizon at right angles, and divides the globe into the eastern and western hemispheres; but in the new method, there is no such brazen circle for the terrestrial globe, nor any need of it in the working any problem thereon; for such a brazen circle according to this method of mounting could never with any propriety be call'd a meridian, because as the sun remains a fix'd body at a distance from the globe, the meridians are constantly varying as the globe is turned about, and are represented by the circles drawn thereon from pole to pole through the given place (or imaginary ones at least) and which being continu'd round the globe, divide it into the two hemispheres aforesaid.

The

The uses of this circle (according to the common method of mounting) are to set the globe to any particular latitude, and to shew the sun or stars declination, right ascension, and greatest altitude.

III. The equator, or equinoctial line, crosses the meridian at right angles, and divides the globe into the northern and southern hemispheres, and represents that very circle in the heavens, which is the sun's apparent path on those two days of the year when the days and nights are equal.

North and south from this circle is reckoned the sun or stars declination on the celestial, and on the terrestrial globe, the latitude of all places according to their distance from the pole.

IV. The ecliptic is the sun's annual, or apparent yearly path, cutting the equinoctial line in two equal points obliquely, at the angles of 23 degrees and

and a half; or more accurately 23° ,
 $29'$; on it are placed the twelve signs,
 through which the sun is supposed
 to pass, viz. *Aries* the ram, γ , *Taurus*
 the bull, δ , *Gemini* the twins, Π , *Can-*
cer the crab, ζ , *Leo* the lion, Ω ,
Virgo the virgin, $\mathfrak{M}$, *Libra* the bal-
 lance, ϵ , *Scorpio* the scorpion, $\mathfrak{M}$,
Sagittarius the archer, $\uparrow$, *Capricornus*
 the sea goat, $\mathfrak{R}$, *Aquarius* the water-
 er, $\mathfrak{W}$, *Pisces* the fishes, $\times$. Each of these
 signs have 30 degrees of the ecliptic
 allotted to it, so that allowing
 360 degrees in the ecliptic, the
 sun (which to appearance moves,
 though in reality it is the earth)
 goes through the whole in 365 days,
 6 hours, and 10 minutes nearly,
 and this is called the periodical,
 or sydercal year; being that time
 in which the sun, leaving any fix'd
 star, returns to it again; and is
 somewhat more than the tropical
 year; which is that portion of time
 in which the sun, departing from
 either

either the equinoctial, or solstitial point, comes to the same again; and consists of 365 days, 5 hours, 48', 57": this difference is caused by the cardinal points of the ecliptic going backwards, or contrary to the order of the signs, 50 seconds of a degree in a year, or one degree in 72 years; and thereby meeting as it were the sun, causes it to return to the same point in the ecliptic, about 21 minutes of time sooner, than to that fix'd star where he would have compleated his revolution.

And here perhaps it may not be amiss, if I should briefly take notice of the reformation made in the kalendar by pope Gregory XIII. Anno 1582, in which year, the vernal equinox was found to happen on the 11th day of March, which at the time of the council of Nice (at which Easter was fixed) A. D. 325, was upon the 21st day of March; he therefore resolved to reform this by bringing the

C

equinox

equinox to its former place; to effect which, he took ten days out of the kalendar, by suppressing ten days in the month of October; and ordering that the fifth day should be called the fifteenth; and to prevent the like variation for the future, ordain'd that every hundredth year should consist of 365 days, whereas in the Julian or old account, it has 366, as being Bissextile or leap-year; excepting every fourth hundred, wherein it was ordered to be retained, because the odd minutes will not amount to more than three days in 391 years.

So that now they who follow this new account, called from its author the Gregorian or new stile, and which is made use of in all Roman Catholic countries, are eleven days before us, who reckon by the Julian or old stile.

Here it is necessary to take notice, that the zodiac is the supposed path of the planets, extending on each side the ecliptic, as far to the north or south side

of

of it, as the planets have ever been observed to go; which distance from the ecliptic is called the latitude of the planet.

V. The two colures are two great circles supposed to pass through the poles of the world, one through the equinoctial points Aries and Libra, call'd the equinoctial colure.

And the other is called the solstitial colure, which going through the points Cancer and Capricorn, does with the former divide the ecliptic into four equal parts.

SECT. II.

Of the LESSER CIRCLES.

The lesser circles are four in Number, *viz.* the tropic of Cancer, the tropic of Capricorn, the Arctic and the Antarctic circles, dividing the globe unequally.

I. The tropic of Cancer is that circle which just touches the extremity of the ecliptic in the northern hemisphere, and describes the sun's path on the longest day in summer; as may be demonstrated to the meanest capacity, by a globe mounted in this new method; a pointer being put through the centre of the sun to the globe, will represent a ray of light falling exactly on that circle, at the time the north pole is at its greatest inclination towards the sun; observe then any particular country on the globe, situated between the equator and the arctic circle, and you will find that the time it takes from its first appearance in the horizon, to its descent below in the opposite point thereof, will be longer than at any other time of the year, and while the globe turns round, if the pointer aforesaid was touch'd with a drop of ink, it would describe the very circle on the globe, we are now speaking of, and would be observed to be at 23 degrees

grees and a half from the ecliptic ; this circle the sun describes about the 11th day of June.

The constant increase and decrease of the days and nights while the sun is journeying through the northern signs, occasion'd by the inclined position of the earth's axis, whereby the northern parts are gradually turned towards it, till he arrives at the first degree of Cancer, when they are at their utmost increase ; are prettily exhibited by this new and ingenious method of mounting the globes. The like may be observed in the southern hemisphere, as the sun travels through the southern signs.

II. The tropic of Capricorn is just the same distance from the equator, on the south side the line, and is the path described by the sun about the 11th of December ; in which case, those countries on the north side the equator will have their shortest days, and those on the southern their longest.

These

These circles, as well as the polar ones, are parallel to the equator, and are called tropics; because when the sun comes at them (they being the limits of his greatest declination, viz. 23° , $30'$) he appears to turn back from his former course towards the equator.

From hence we are naturally led to the third and fourth lesser circles, called the polar, which are the arctic, and the antarctic, the former being 23 degrees and a half from the north pole, and the latter, the same number from the south pole; when the sun enters the tropic of Capricorn, the whole arctic circle will be found to be wholly under the horizon; consequently all the countries within the same are deprived of seeing the sun's body; on the other hand, when he enters the tropic of Cancer, all those very countries may be observed (as the globe is rolled round) never to descend below the horizon, and therefore lose not the sight of him; which at once manifests the reason, why

in

in the former case they have a continued night without day ; and in the latter, a continued day without night ; and the same to each pole alternately.

SECT. III.

Of the several POINTS on the GLOBES.

The two first of these are the two poles we have been speaking of, that is, the north and south poles ; correspondent to which are the poles of the heavens ; these seem ever steadfast, and around them not only the earth, but the heavens, with all their numerous host, appear to turn : the third and fourth are the zenith and nadir ; the first being exactly over our heads, and the latter exactly under our feet ; and may properly be called the poles of our horizon, being equally distant therefrom 90 degrees every way ; next to these are the two poles of the ecliptic ; which are the points to which the earth in its annual orbit hath respect ; these poles are distant

23° 30' from the poles of the world, or of the equinoctial, and are both situated in the solstitial colure; by these are the polar circles described in the diurnal motion of the earth round its axis; whence it should appear that these two circles are called polar: the next points are the four cardinal ones, call'd East, West, North, and South; and the four last are the solstitial points, which are the beginning of the signs Cancer and Capricorn, in the ecliptic line, and the two equinoctial points, where the ecliptic cuts the equator; these four divide the ecliptic into the four quarters of the year, *viz.* spring, summer, autumn, and winter.

Every part of the earth is supposed to have a meridian line passing through its zenith, from north to south, through the poles of the world; as being the line on which the sun is exactly at noon; these

me-

meridians are various, and change according to the longitude of places, which longitude is their distance from the meridian of any given place, either east or west; and here it may be proper to observe, that a number of these lines thus drawn, will be of very different distances from each other, as they advance from the equator towards either pole; for which reason, as the whole is divided into 360 degrees on the equator, and each degree contains 60 geographical, or 69 and half English miles, every step you take towards the pole will lessen the number of miles in a degree of longitude, in such a manner that at the latitude of London, you will find but $37\frac{32}{100}$ miles contained in a degree there, and at the 60th parallel of latitude no more than 30 to a degree; thus decreasing as the parallels lie nearer the pole, till at last they centre in the pole itself, as may be observed by the following table.

D

A

A TABLE shewing the Quantity of a Degree of Longitude in every Parallel of Latitude.

	Lat.	Min.	Sec.		Lat.	Min.	Sec.
Equator	0	60	0		24	54	48
Parallel	1	59	56		25	54	24
	2	59	54		26	54	0
	3	59	52		27	53	28
	4	59	50		28	53	0
	5	59	46		29	52	28
	6	59	40		30	51	56
	7	59	37		31	51	24
	8	59	24		32	50	52
	9	59	10		33	50	20
	10	59	0		34	49	44
	11	58	52		35	49	8
	12	58	40		36	48	32
	13	58	28		37	47	56
	14	58	12		38	47	16
	15	58	0		39	46	36
	16	57	40		40	46	0
	17	57	20		41	45	16
	18	57	4		42	44	36
	19	56	44		43	43	52
	20	56	24		44	43	8
	21	56	0		45	42	24
	22	55	36		46	41	40
	23	55	12		47	41	0

A TABLE shewing the Quantity of a Degree of Longitude in every Parallel of Latitude.

Lat.	Min.	Sec.	Lat.	Min.	Sec.
48	40	8	70	20	32
49	39	20	71	19	32
50	38	32	72	18	32
51	37	44	73	17	32
52	37	0	74	16	32
53	36	8	75	15	32
54	35	26	76	14	32
55	34	24	77	13	32
56	33	32	78	12	32
57	32	40	79	11	28
58	31	48	80	10	24
59	31	0	81	9	20
60	30	0	82	8	20
61	29	4	83	7	20
62	28	8	84	6	12
63	27	12	85	5	12
64	26	16	86	4	12
65	25	20	87	3	12
66	24	24	88	2	4
67	23	28	89	1	4
68	22	32	90	0	0
69	21	32			

Dz

The

The latitude of a place is its distance from the equator towards the north or south pole ; and is always equal to the elevation of the pole above the horizon of that place. The degrees of it are of the same length all round the globe ; because the parallels, which bound them, are equidistant : Therefore to find the latitude of any place, observe how many degrees the pole star is above the horizon, which in London being 51 degrees, 32 minutes, we accordingly say, the latitude of the said place is just so much.*

If you travel ever so far, directly east or west, you still keep in the same latitude, but are continually varying your longitude ; on the other hand travel as far as you please directly north or south, you will keep in the same longitude, but constantly vary in your latitude.

* The pole star, so called on account of its being the nearest of the visible stars in its situation towards the north pole, but is not in the pole itself, being something more than two degrees from it ; to work an observation by this star, consult Kelly's Modern Navigator's Compleat Tutor.

SECT. IV.

Of the Division of the Earth into
CLIMATES and ZONES.

A climate, is a part or portion of the earth comprehended between two such parallels of latitude, that the distance betwixt them shall cause half an hour's difference in the longest day: They are in number sixty, viz. thirty on each side the equator, up to the poles; 24 of which are posited between the equator and the polar circles, of half an hour increase each; and six between the polar circles and the poles, where the increase is by months. A table of which, with the quantity of the longest day, the beginning, middle, ending, &c. of each, is as follows.

22	22	17	17	11
23	23	17	17	11
24	24	17	17	11
25	25	17	17	11
26	26	17	17	11
27	27	17	17	11
28	28	17	17	11
29	29	17	17	11
30	30	17	17	11
31	31	17	17	11
32	32	17	17	11
33	33	17	17	11
34	34	17	17	11
35	35	17	17	11
36	36	17	17	11
37	37	17	17	11
38	38	17	17	11
39	39	17	17	11
40	40	17	17	11
41	41	17	17	11
42	42	17	17	11
43	43	17	17	11
44	44	17	17	11
45	45	17	17	11
46	46	17	17	11
47	47	17	17	11
48	48	17	17	11
49	49	17	17	11
50	50	17	17	11
51	51	17	17	11
52	52	17	17	11
53	53	17	17	11
54	54	17	17	11
55	55	17	17	11
56	56	17	17	11
57	57	17	17	11
58	58	17	17	11
59	59	17	17	11
60	60	17	17	11

A

A TABLE of Climates and Parallels.

Climates	Parallels	Longest Day		Latitude	
		ho.	min.	deg.	min.
1	beginning	12	00	0	00
	middle	12	15	4	15
	end	12	30	8	25
2	middle	12	45	12	30
	end	13	00	16	25
3	middle	13	15	20	15
	end	13	30	23	50
4	middle	13	45	27	40
	end	14	00	30	20
5	middle	14	15	33	40
	end	14	30	36	28
6	middle	14	45	39	02
	end	15	00	41	22
7	middle	15	15	43	32
	end	15	30	45	29
8	middle	15	45	47	20
	end	16	00	49	01
9	middle	16	15	50	53
	end	16	30	51	58
10	middle	16	45	53	17
	end	17	00	54	27
11	middle	17	15	55	34
	end	17	30	56	37
12	middle	17	45	57	32
	end	18	00	58	29
13	middle	18	15	59	14
	end	18	30	59	58

A TABLE of Climates and Parallels.

Climates	Parallels	Longest Day	Latitude
		ho. min.	deg. min.
14	middle end	18 45 19 00	60 40 61 18
15	middle end	19 15 19 30	61 55 62 25
16	middle end	19 45 20 00	62 54 63 22
17	middle end	20 15 20 30	63 40 64 06
18	middle end	20 45 21 00	64 30 64 49
19	middle end	21 15 21 30	65 06 65 21
20	middle end	21 45 22 00	65 35 65 47
21	middle end	22 15 22 30	65 57 66 06
22	middle end	22 45 23 00	66 14 66 20
23	middle end	23 15 23 30	66 25 66 28
24	middle end	23 45 24 00	66 30 66 31
Months			
25		1	67 30
26		2	69 30
27		3	73 20
28		4	78 20
29		5	84 00
30		6	90 00

The Use of the foregoing Table.

By this table, the length of the longest day in any latitude may be readily found: For Instance, the latitude of Peking, the capital of China, being $39^{\circ} 55'$, it is evident according to the table, that it lies within the 6th climate; its longest day therefore will be near 15 hours; whereas Peterburgh in Russia, lying in latitude $59^{\circ} 58'$, at the end of the 13th, or beginning of the 14th climate, its longest day is 18 ho. 30'.

II. A zone, is a broad circular band, or space encompassing a large tract, or portion of the earth; these are five in number, covering the surface of the whole globe, viz

The two *Frigid Zones*, included between the two polar circles and the poles; and consequently always have the sun at a great distance from them, being hid at some certain seasons entirely from his sight, for a considerable time together; and thereby exposed to the

the utmost severity and inclemency of cold, necessarily resulting from thence.

The two next are the *Temperate Zones*, so called, by being happily seated between the two frigid ones aforesaid; and the torrid zone; and occupy all that space from the tropics, to the polar circles; the inhabitants of these two zones can never have the sun directly over them, or in their zenith; nor is their situation such, as to be deprived of his all-cheering and enlivening presence, for the space of a natural day, or 24 hours of time.

The *Torrid Zone*, is all that portion of the earth which lies between the two tropics, the equator passing through the middle thereof: to every part of this zone the sun is vertical, or perpendicular, twice in the year, at one time or other; darting his beams directly upon the heads of its inhabitants; scorching and heating the whole tract to a very great degree (hence its name) inasmuch that the ancients, on this

this account, believed it to be wholly uninhabitable; but later discoveries have refuted this error, and shewn us that many populous, rich, and powerful nations dwell therein.

S E C T. V.

Of the Division of the Earth into **LAND and WATER.**

The most natural division of the earth, is that of Land and Water; the several parts of which may be enumerated and consider'd under the following heads; and seem to have a similar relation, or analogy to one another.

LAND.

A Continent, is a large extent of land, containing many countries and kingdoms, and is not distinguished or separated by seas; as Europe, Asia and Africa; called the old world or America, by some called the new world.

An Island is a tract of land environ'd round with

WATER.

An Ocean (or great sea) is a vast collection, or extent of water; such is the Atlantic, or Western Ocean; the German Ocean, the Indian Ocean, &c.

A Lake, is a tract of water, surrounded by land, as the Lake of Geneva; the Lake Asphaltites.

This is also said by some authors of Note, to be the very spot whereon Sodom and Gomorrah stood.

A. The Channel between the River
 B. The River to the Lake
 C. The River to the Lake
 D. The River to the Lake
 E. The River to the Lake



- A The Continent answers to A the Ocean.
 B An Island to B a Lake.
 C A Promontory to C a Bay.
 D A Peninsula to D a Gulf.
 E An Isthmus to E a Strait.



L A N D.

waters or sea, as Great-Britain, Ireland, &c.

A Promontory, is a part of land running a great way into the sea, the extremity of which is called a cape; as Cape Bajador, Cape Verde, Cape of Good Hope, &c.

A Peninsula, is a portion of the earth furrounded with water or sea, save that narrow neck of land which ties it to the continent; as Africa, North and South America, &c.

An Isthmus, is that part of land, by which a peninsula is joined to the Terra Firma, or main land; as the Isthmus of Suez, whereby Africa has communication with Asia; and that of Panama, which joins North and South America together, &c.

As to other Parts, such as Rivers, Mountains, &c. they need no explanation.

But for the better illustrating this matter, I have, for the use of young beginners, annexed a draught or map, where the several particulars here mention'd are set forth in a clearer view.

W A T E R.

(called also the Dead Sea) and the Caspian Sea, &c.

A Bay, is a portion of the sea, running far up into the country, and terminates by the land; as the Bay of Biscay, Bay of Siam, &c.

A Gulph (or inland sea) is a part of the ocean encompassed with land, except that narrow gut of water, by which it is communicated with the ocean, &c. as the Mediterranean Sea, the Arabian Gulph, or Red Sea, &c.

A Strait, is that narrow passage which joins one sea, &c. to another; as the Streights of Gibraltar, which joins the Atlantic Ocean to the Mediterranean Sea; the Streights of Babelmandel, joining the Red Sea, or Arabian Gulph, to the Indian Ocean, &c.

SECT. VI.

Of the AMPHISCII, PERISCII, HETEROSCII, ANTOECI, PERIOECI, *and* ANTIPODES.

The earth may also be consider'd with regard to its inhabitants, and they by Geographers are distinguished into the following classes, *viz*,

- I. Either in respect of their shadow; and then they are divided into *Amphiscii*, *Periscii*, and *Heteroscii*, or,
- II. In regard to their situation; and then they are ranged under the names of *Antoeci*, *Perioeci*, and *Antipodes*.

I. As to their shadow.

Amphiscii, this appellation is given to those who dwell between the two tropics, or in the torrid zone; because their shadows fall on both sides of them, *viz*. to the south, when the sun is beyond them in the northern signs;

signs; and to the northward, while the sun is going through the southern signs; but at such times as the sun is vertical to them, which is twice in the year; the inhabitants of such places, in whose zenith he then is, have no shadows.

Periscii, so the inhabitants of the two frigid zones, or such as dwell beyond the polar circles, are called; because, as the sun, after he is once risen, runs quite round them, all the time he is above their horizon; so are their shadows cast around, or on every side of them: Whence the name.

Heteroscii, are such as dwell between the two tropics and the polar circles, or in the two temperate zones; and are so called, because their shadows are cast but one way, *viz.* in north latitude, to the northward; and in south latitude, always to the southward of them.

II. In respect to their situation.

Antoeci, are such as dwell under the

the same meridian, and in the same parallel of latitude, but on the opposite side the equator, the one north, the other equally distant south therefrom; the consequence of such a position is, that their noon and midnight are at the same time; their shadows fall different ways; the days of the one, are equal to the nights of the other; and the one's summer, is the others winter.

Perioeci, are such as dwell under the same parallel of latitude, on the same side the equator, and under the same meridian, but in opposite points thereof; being 180 degrees different in longitude: hence the seasons of the year, and length of days, are alike to both; only 'tis mid-day with the one, when it is mid-night with the other; the length of the days to one, is the complement of the others nights; they are equally distant from the equator; have the same pole elevated and depressed; and the phenomena

mena of the heavenly bodies are to both of them alike.

Antipodes, are those that dwell feet to feet, or diametrically opposite to one another, being under the same meridian, but in different semicircles thereof, and distant from one another 180 degrees, or half the periphery of the earth; the one as far from the equator north, as the other is to the south; consequently, the contrary poles are equally elevated; and they differ in all things, as seasons of the year, length of days (the longest day in one, being the shortest in the other) rising and setting of the sun, &c.

SECT. VII.

Of the various POSITIONS of the globe or sphere.

The several positions of the sphere, are three, *viz.*

- I. A direct, or right sphere,
- II. A parallel sphere,
- III. An oblique sphere.

I. A direct or right sphere, is when the poles of the world are in the horizon, and the equator passeth through the zenith, which can happen to none but those who live under the equinoctial line, where the inhabitants have no latitude, no elevation of the pole; to whom the sun, and moon, the planets, and fixed stars do all rise and set at right angles; they have two summers, and two winters, though even in their winters, the sun is nearer to them, than to us in the midst of our summer; and though their seasons differ, their days and nights are equal.

II. A parallel sphere, is when the poles of the world are in the zenith and nadir, the equator in the horizon, and all the parallels of latitude running parallel with the horizon, to whose inhabitants, the sun's highest altitude can never be more than 23 degrees and a half; all the stars that are visible to them

them, make perpetual revolutions round them, and are never seen either to rise or set; nor are higher or lower; and to whom all the planets appear half their periods above, and half below their horizon; so that Saturn in places near the pole does not appear above their horizon for fifteen years together, nor doth the sun afford them his presence more than half his yearly course; nevertheless we must not deceive ourselves so far as to think them totally involved in night and darkness, during his tedious absence of six months; no, on the contrary, so great is the obliquity of the sun's rays, he being two months before he retreats 18 degrees below their horizon, which is, nearly, the point where the rays are first admitted into the atmosphere, and but two months more before he arrives at the like point again, that they consequently enjoy a very large degree of twilight, to which if we add the light of the moon, which must be greatly increased by the reflection of the snow upon the ground,

the surprising brightness of the Aurora Borealis, or northern lights, in those parts, together with the refraction of the rays through the thick air or atmosphere, which causes the sun to appear above their horizon several days sooner, and disappear several days later than otherwise it would do; we shall perceive that upon the whole, the Polar inhabitants (if there be any) enjoy a greater share of light than any other people under the heaven.

III. An oblique sphere, is where the elevation of the pole is less than 90 degrees above the horizon; to the inhabitants of this sphere, (which is the case of all, except those directly under the equator, and the poles themselves) one pole of the world is always in view, and the other never seen; also some stars never set, and others never rise in their horizon; and those which are seen, together with the sun, moon, and all the planets, appear to rise and set at oblique angles thereto; their

their days and nights likewise vary in their length, according to the different declination of the sun, in the several seasons of the year.

Thus much with respect to the terrestrial globe.

SECT. VIII.

Of the CELESTIAL GLOBE, the Constellations depicted thereon, with a Table of the Latitudes, Longitudes, Magnitudes, and Number of Stars, in each Constellation.

As the terrestrial globe is parcel'd out into several parts and divisions, and furnished with various circles and lines, &c. so also is the celestial one, which is bespangled with stars; that therefore astronomers might be the better enabled to tell the number of those bright and glorious luminaries, and to call them all (as it were) by their names, as well as more readily to communicate what future discoveries they might make

in those vast and immense regions, with regard to the appearance of any new star, and for the better conveying just and regular notions of the magnitudes, distances, places, &c. of those already known, they have digested these numerous celestial bodies into forms of animate and inanimate beings or things, called by them asterisms or constellations, (all which are drawn upon this Globe) such as the great and little Bears, the Dragon, the Harp, &c.; a catalogue or table of which follows, with their names, latitudes, and longitudes, the number of the stars in each constellation, distinguished into seven degrees of magnitude, and rectified for the Year 1686, as I find the same published by Mr. Martin, in his *Philosophia Britannica*, and which, he tells us, is taken from Mr. Flamsteed's third volume of his *Philosophia Caelestis*, as such I hope it will not be unacceptable to some readers.

well as more readily to communicate
the same discoveries they might make
in

The Constellations of the Twelve Signs.

Names.	Longitude.	Latit.	Num.	Magnitude.						
				1	2	3	4	5	6	7
Aries, the ram.	♈ 26° 48' 00" 1' S ♈ 21 6 12 31 N	00° 1' S 12 31 N	65	0	1	2	5	6	28	23
Taurus, the bull.	♉ 16 49 18 27 S ♉ 26 36 9 46 N	18 27 S 9 46 N	135	1	1	4	13	21	44	51
Gemini, the twins.	♊ 14 11 10 7 S ♊ 12 33 13 18 N	10 7 S 13 18 N	79	1	2	4	6	12	32	22
Cancer, the crab.	♋ 22 49 10 19 S ♋ 12 19 14 59 N	10 19 S 14 59 N	71	0	0	0	6	7	39	19
Leo, the lion.	♌ 10 57 7 39 S ♌ 20 42 17 38 N	7 39 S 17 38 N	95	2	2	6	15	10	50	10
Virgo, the virgin.	♍ 00 10 00 24 S ♍ 29 23 21 24 N	00 24 S 21 24 N	89	1	0	5	10	19	45	9
Libra, the ballance.	♎ 4 11 18 34 N ♎ 28 35 11 27 S	18 34 N 11 27 S	49	1	2	7	5	11	21	2
Scorpio, the scorpion.	♏ 26 48 12 46 N ♏ 20 46 13 57 S	12 46 N 13 57 S	51	0	2	2	12	5	25	5
Sagittarius, the archer.	♐ 22 55 10 59 S ♐ 26 29 7 31 N	10 59 S 7 31 N	50	0	1	5	6	11	23	4
Capricornus, the goat.	♑ 27 26 8 53 S ♑ 21 29 7 27 N	8 53 S 7 27 N	51	0	0	3	3	9	34	2
Aquarius, the waterer.	♒ 7 24 21 4 S ♒ 21 57 23 2 N	21 4 S 2 2 N	99	1	0	4	7	31	50	6
Pisces, the fishes.	♓ 11 6 23 6 S ♓ 26 47 9 5 N	6 23 S 9 5 N	109	0	0	1	6	27	54	21

The Constellations of the Northern Hemisphere.

Names.	Longit.	Latit.	Num.	Magnitude.						
				1	2	3	4	5	6	7
Andromeda ^a	Υ 3° 29' 18" 49"	15° 55' 49" 53"	66	0	3	2	12	13	34	δ E W
Aquila, cum Antinoo, the eagle with Antinous ^b	Ψ 29° 46' 8" 6"	10° 5' 43" 27"	70	1	0	10	7	15	32	5
Anser cum Vulpe, the goose with the fox	Ψ 20° 20' 1" 14"	37° 39' 47" 46"	34	0	0	0	4	12	18	0
Auriga, the waggoner	Π 11° 22' 12" 30"	2° 29' 32" 13"	68	1	2	1	10	18	31	5
Bootes, the herdsman	Υ 22° 34' 0" 54"	25° 15' 60" 33"	55	4	0	8	10	11	17	8
Cassiopeia ^c	Υ 21° 6' 8" 45"	38° 18' 59" 53"	56	0	0	5	7	9	30	5
Camelopardus ^d	Π 10° 40' 10" 39"	29° 24' 45" 43"	58	0	0	0	4	18	27	9
Cepheus ^e	Υ 00° 39' 26" 37"	59° 32' 75" 27"	35	0	0	3	7	8	14	3
Coma Berenices, Berenice's hair ^f	Υ 16° 53' 4" 38"	15° 14' 33" 56"	40	0	0	0	8	14	14	4
Corona Septentrionalis, the northern crown	Π 0° 58' 20" 54"	44° 21' 56" 25"	21	0	1	0	6	8	6	0
Cygnus, the swan	Ψ 20° 55' 23" 17"	37° 39' 74" 10"	107	0	1	6	21	31	48	0

^a Andromeda, the daughter of Cepheus, king of Ethiopia, whom Perseus delivered from a sea monster.

^b Antinous, a youth greatly

beloved by the emperor Adrian.

^c Cassiopeia, the mother of

Andromeda.

^d Camelopardus, a beast so called

^e Cepheus, the

father of Andromeda.

^f Berenice, the sister of Ptolemy Euergetes

king of Egypt, and second wife to Antiochus Theos, by whose son and successor, Seleucus Callinicus, she was basely murder'd at the instigation of his mother Laodice.

The

The Northern Constellations continued.

Names.	Longit.	Latit.	Num.	Magnitude.						
				1	2	3	4	5	6	7
Delphinus, the dolphin	$\equiv$ 8° 49' 16" 31"	23° 00' 33" 44"	18	0	0	6	0	2	9	1
Draco, the dragon	Per totam circumfer. thro' the whole circumference.	57 13 87 25	49	0	1	7	8	13	19	1
Equuleus, the horse-colt	$\equiv$ 14 12 21 7	20 09 25 13	10	0	0	0	4	1	5	0
Hercules ^s	$\equiv$ 28 7 28 29	25 15 69 33	95	0	0	11	15	31	38	6
Leo minor, the lesser lion	$\equiv$ 29 8 4 4	9 21 30 50	53	0	0	1	5	11	33	3
Lacerta, the lizard	$\equiv$ 19 49 6 27	43 12 55 34	16	0	0	0	3	6	7	0
Lynx ^h	Ω 28 24 9 45	17 3 40 39	44	0	0	0	3	12	21	8
Lyra, the harp	$\equiv$ 3 35 26 14	54 28 66 13	21	1	0	2	2	5	11	0
Perseus, C. M.	$\equiv$ 8 8	11 17								
Perseus with Medusa's head ⁱ	Π 10 48	41 13	67	0	2	5	11	15	28	6
Pegasus, the flying horse	$\equiv$ 23 37 7 17	9 13 44 24	93	0	4	3	10	13	58	5

^s Hercules, the son of Jupiter, by Alcmena, the wife of Amphitryo, king of Thebes. ^h Lynx, a wild beast so called.

ⁱ Perseus, the son of Jupiter by Danae, the daughter of Acrisius, king of the Argives, and the deliverer of Andromeda; the vanquisher also of Medusa, the Gorgon, whose head he cut off and placed it upon his shield.

The

The Northern Constellations continued.

Names.	Longit.	Latit.	Num.	Magnitude.						
				1	2	3	4	5	6	7
Sagitta, the dart	♊ 20° 00' 8 37	35° 35' 43 15	23	0	0	0	4	1	18	0
Serpens Ophiuchi, Ophiuchus's serpent	♏ 7 38 11 31	7 59 42 28	59	0	1	7	6	3	32	10
Scutum, the shield	♊ 0 23 10 8	4 59 18 17	7	0	0	0	2	4	1	0
Serpentarius, or Ophiuchus, the serpent-bearer	♏ 27 58 1 29	6 54 37 18	69	0	1	7	15	13	20	7
Triangulum, the triangle	♊ 0 5 13 15	55 20 34	15	0	0	0	3	1	7	4
Ursa major, the great bear	♊ 10 41 6 58	17 6 3	245	0	6	5	35	58	91	20
Ursa minor, the little bear	♊ 21 43 17 19	65 42 50	24	0	0	4	3	5	6	6
Canes Venatici, the Greyhounds	♊ 0 5 25 43	52 56 33	25	0	1	0	2	5	14	3

The

The Constellations of the Southern Hemisphere.

Names.	Longit.	Latit.	Num.	Magnitude.						
				1	2	3	4	5	6	7
Ara cum Thuri- bulo, the altar with the censer	♄ 15° 6' 23° 5' 27 18 37 15		9	0	0	1	6	2	0	0
Argo, or Navis, the ship *	♊ 24 57 22 24 ♏ 14 249 14		25	0	0	4	6	6	9	0
Apus, the Bird of Paradise	♄ 9 45 44 32 21 24 62 4		11	0	0	0	4	3	4	0
Canis major, the great dog	♏ 3 7 34 44 ♊ 25 12 59 14		32	1	7	1	4	11	5	3
Canis minor, the little dog	♊ 16 48 9 45 ♏ 0 49 23 47		15	1	0	1	0	3	9	1
Cetus, the whale	♊ 18 36 2 42 ♏ 14 30 34 14		78	0	2	6	13	9	44	4
Centaurus cum Lupo, the Centaur with the wolf	♊ 25 42 11 28 ♏ 28 30 21 59		13	0	1	0	5	6	1	0
Cameliontis, the Cameleon	♏ 26 30 63 35 ♄ 3 39 75 24		10	0	0	0	0	9	1	0
Columba Noahi, Noah's dove	♏ 14 54 55 42 ♊ 6 46 60 41		10	0	2	0	1	6	1	0
Corona Australis, the southern crown	♏ 1 18 12 28 10 14 22 36		12	0	0	0	1	3	8	0
Corvus, the crow	♊ 6 20 10 21 13 3 21 44		10	0	0	3	2	2	3	0

* Argo, the name of the ship in which Jason with his companions went to Colchis, to fetch from thence the golden fleece.

The Southern Constellations continued.

Names.	Longitude.	Latit.	Num.	Magnitude.						
				1	2	3	4	5	6	7
Crater, the cup	Υ 19° 26' 3 58 Ξ	11° 18' 22 42	11	0	0	0	8	2	2	0
Eridanus, the river ^k	Υ 16 38 18 26 Π 11 15 54 33	68	0	0	12	15	20	20	1	
Grus, the crane	Ξ 14 54 39 43 18 241 55	3	0	0	0	2	1	0	0	
Hydrus, the snake	Ψ 26 59 64 10 Υ 3 37 78 5	10	0	0	4	2	3	1	0	
Lepus, the hare	Π 6 44 34 45 28 945 46	19	0	0	3	7	3	6	0	
Musca, the fly	$\mathfrak{M}$ 16 20 55 11 22 22 58 47	4	0	0	0	2	2	0	0	
Monoceros, the unicorn	Π 29 34 13 13 Ω 10 50 31 11	19	0	0	0	10	7	2	0	
Orion ^l	Π 7 52 3 11 Φ 15 11 34 4	80	2	4	4	25	20	25	0	
Pavo, the peacock	$\mathfrak{P}$ 24 7 36 11 Ψ 24 41 50 49	14	0	1	3	5	4	1	0	
Phœnix ^m	Ξ 29 47 31 39 $\times$ 24 14 55 5	13	0	1	5	6	1	0	0	
Piscis volans, the flying fish	Ξ 11 19 67 52 $\mathfrak{M}$ 14 11 82 35	8	0	0	0	0	7	1	0	
Robur carolinum, the oak	Ξ 3 34 51 2 $\mathfrak{M}$ 7 6 72 12	12	0	1	2	7	2	0	0	

^k Eridanus a River in Italy, the same with the Po, famous among the Poets for the fall of Phaeton.

^l Orion, a great hunter, kill'd by a scorpion.

^m Phœnix, the name of a very rare bird.

The

The Southern Constellations continued.

Names.	Longit.	Latit.	Num.	Magnitude.						
				1	2	3	4	5	6	7
Sextans, the sextant ^a	♋ 19° 59' 13" 5	1° 21' 19" 43	41	0	0	0	1	7	32	1
Touchan ^b	♊ 3° 16' 22" 43	45° 27' 59" 46	9	0	0	4	2	3	0	0
Triangulum, the triangle	♊ 5° 35' 17" 2	41° 32' 48" 1	5	0	1	2	0	2	0	0
Xiphias, the sword-fish	♊ 7° 36' 18" 3	70° 12' 88" 14	6	0	0	1	2	1	2	0
Num.				1	2	3	4	5	6	7
In the Zodiac —	943	7	11	43	94	169	445	174		
In Northern Hemisphere	1511	4	23	93	227	356	695	113		
In Southern Hemisphere	547	4	20	56	136	145	176	10		
Sum of all the Stars —	3001	15	54	192	457	670	1316	297		

* Besides these constellations, a variety of circles are also drawn on this globe, corre-

^a Sextant, the name of a mathematical instrument.

^b Touchan, a bird so called.

* Here I can't help observing how much the world will be indebted to the same gentleman, who has made this improvement of the globes, for his indefatigable perseverance in conjunction with another, whose known skill in astronomy has justly rendered him the admiration of *All*, in bringing to perfection such a compleat view of the heavens as was never before exhibited to the world, in 50 copper plates representing all the constellations in an elegant manner, with proper explications to each particular; which has been the effect of several years labour, and now near the delivery; they will make a very neat appearance, but I need say no more here, as they may be inspected at large, at his own house, by all who are inclined to do it.

corresponding with those on the terrestrial; only it must be observed, that such as are called meridians, and by some lines of longitude, on that, are here called hour circles (when drawn at every fifteen degrees) and also circles of ascension, because by them the eye is directed to the true hour, or right ascension of the sun or any star, tho' at ever such a distance from it.

SECT. IX.

Containing some NECESSARY DEFINITIONS.

I. The declination of the sun or any star, is its distance from the equinoctial northward or southward, reckoned on the meridian in degrees and minutes, in the same manner as latitude is on the terrestrial globe; which, if it be towards the north pole of the world, is called north declination, but if towards the south pole, south declination.

II. The

II. The latitude of a star or planet is its distance from the ecliptic, north or south, reckoned in degrees from the ecliptic towards its poles.

III. The longitude of a star or any point in the heavens, is an arch of the ecliptic, intercepted between the circle of longitude * passing through that star, &c. and the first point of the beginning of Aries, and is the same as its distance from the equinoctial point Aries measured on the ecliptic, and reckoned according to the order of the signs.

IV. The altitude of the sun or star is an arch of an azimuth circle, || contained between the center of the star and

* Circles of longitude on the celestial globe are large circles intersecting each other in the poles of the ecliptic, as the meridians or hour circles do in the poles of the world; they are commonly drawn through the beginning of every sign, but are all represented by the quadrant of altitude screwed over one of the poles of the ecliptic, as are also the parallels of latitude by the graduations marked thereon.

|| Azimuths, or vertical circles, are great circles cutting one another in the poles of the horizon (or zenith and nadir) as the circles of longitude do in the poles of the ecliptic, and are all of them supplied together with the almucantars, or parallels of altitude, which are circles running parallel to the horizon, by the quadrant of altitude when screwed in the zenith.

and the horizon; or, it is the height of the sun or star above the horizon, counted on the quadrant of altitude, and, respect being had to the sensible and rational horizon, is either true or apparent.

The true or real altitude is its elevation above the real or rational horizon; and the apparent altitude is its apparent elevation above the sensible horizon.

V. The depression of the sun or star is its distance below the horizon.

VI. Amplitude of the sun or stars, is the difference or distance at their rising or setting, from the east or west points of the horizon, towards the north or south points thereof, which for rising is called amplitude ortive, and for setting, occasive amplitude.

VII. Azimuth of the sun or stars, is an arch of the horizon, contained between the point, where the vertical circle or azimuth, passing through the body of the sun or star, intersects the horizon, and the north or south points thereof.

thereof : so that the difference between the amplitude and the azimuth is this ; the amplitude shews the bearing of any object, as the sun, a star, &c. at its rising or setting, from the east or west points of the horizon ; and the azimuth, its bearing, when it is risen above the horizon, either from the north or south points thereof ; for instance, if a star rises or sets within 15 degrees of the east or west, suppose towards the south, its amplitude is accordingly said to be 15 degrees southerly ; but if a star be risen any height above the horizon, and should happen to be in the same vertical circle passing through the point aforesaid, we say its azimuth is 75 degrees from the south, or 105 degrees from the north, which is the same thing.

VIII. Right ascension of the sun, or star, is that degree of the equinoctial, reckoned in degrees and minutes from the beginning of Aries, which cometh to the meridian with the sun, or star, or which riseth with it, in a right or direct sphere ; for then the poles of the world

world lying in its horizon, the meridian is always at right angles to the equinoctial, and is the reason of referring it thereto.

IX. Oblique ascension is the degree and minute of the equinoctial, which cometh to the horizon, or riseth with the sun or star in an oblique sphere.

X. Oblique descension, is that part of the equinoctial which sets with the sun or star in an oblique sphere.

XI. Ascensional difference is the difference between the right and oblique ascension or descension, or it is the time of the sun or star's rising or setting before or after 6 o'Clock.

XII. A star is said to be vertical or in the zenith, when directly over our heads; and in the nadir, when it is in the opposite point, or directly under our feet.

XIII. A star is said to rise cosmically, when it rises with the sun, and to set cosmically, when it goes down or sets in the west at the same time the sun rises in the east.

XIV. A

XIV. A star rises anachronically, when it rises at the time the sun sets, and sets anachronically, when it goes down or sets at the time the sun rises.

XV. A star is said to rise heliacally, when it is just come to such a distance from the sun, as to be no longer hid by his beams, and to set heliacally, when it is so near the sun as to be hid by the rays of that more glorious luminary.

Thus having gone through the introductory articles relating to the use of the globes, I now proceed to the main business of this tract as a supplement to all other treatises of the like kind; not that I would be thought more knowing than those who were the authors of those excellent pieces, or that I had a happier genius or clearer manner of expression, whereby more readily and with greater facility to convey my sentiments or conceptions to the minds of others; on the contrary (thoroughly sensible of my own insufficiency) neither the worth of the invention, nor the necessariness, not to say necessity, of something of this sort to be undertaken,

H occasioned

occasioned by so rare an improvement in art, could prevail with me to engage in the attempt, till I found that notwithstanding the increase of inquiries relative thereto, yet no one had made any advance towards it, which I hope will sufficiently excuse me to every candid and impartial Reader: I shall therefore without any further apology begin with shewing wherein this method differs from the former in mounting, and then proceed to illustrate its superior excellencies, in the solution of a great variety of curious and entertaining problems.

S E C T. X.

Containing a more particular Description of Mr. NEALE's new Method of mounting the Globes, by the Application of an Abridgment of his Planetary Machinery, for which he obtained the Royal Patent in the 18th Year of his present MAJESTY.

I begin with the terrestrial, which is mounted with the horizon fix'd vertical,

cal, and the globe placed to move therein upon its own axis, thereby to represent its diurnal motion; besides which, it also moves upon the axis of the ecliptic, to demonstrate all the mutations of the seasons, from its annual motion. At a distance from the globe is a ball, to represent the sun, which remains fix'd; and from the north-pole some wheel-work is placed to convey a motion to the moon, which moves round the globe, and between it and the sun in 29 days and a half from one conjunction to another, but round the earth itself in less than 27 days and a half: Through the center of the sun runs a piece of steel, called a pointer, to take in and out at pleasure, which represents a direct ray from the sun, and (by means of some wheel-work at the south pole) shews all those countries, to which the sun at any particular time is vertical, and if observed six months successively, or while the sun is passing from one equinoctial point to the other, or from tropic to tropic, will afford a pretty appearance. Suppose,

Suppose, for instance, the sun to be in the northern tropic, or that of Cancer, by this pointer will be shewn, as the globe is turned about, that a vertical ray represents a spiral line round the earth, from the tropic of Cancer to that of Capricorn, and then back again from Capricorn to Cancer, each line every day at noon falling at the distance of about seven minutes from that of the preceding day; which being so clearly demonstrated by this method of mounting, it is impossible for any master of a family to have much trouble, in giving his children a very just idea of the true cause of all the variations of the seasons, even from this particular; for, from hence, a youth will be naturally led to examine why this phenomenon happens, when upon a diligent observation he will soon perceive, that it springs from the north pole receding more and more from the sun, by the earth's advancing in its annual circuit: Thus, let us suppose it now to be the renth of June, the pointer

pointer then falls directly on the tropic
 of Cancer, when it will be observed,
 that all the countries on the north side
 of the equator have their days at the
 greatest length, and that this length in-
 creases with their distance from the
 equator; hence also the youth will
 perceive the true natural cause of its
 being all day and no night, to all the
 inhabitants within the arctic circle,
 whilst the reverse of this happens to
 those who people the antartic; and as
 he turns about the globe, to observe his
 pointer approaching the equator, he
 will be no less agreeably entertained in
 viewing as many degrees within the
 arctic circle roll below the horizon, as
 his pointer has receded from the afore-
 mentioned tropic, till it arrives at the
 equinoctial line, when it will appear
 self-evident, why the days and nights
 are then equal all the world over, by
 noticing that the south pole, which be-
 fore never appeared above the horizon,
 now shews itself even with it, while at
 the same time the northern one, which

was

was before so much elevated above it,
 is now upon a level therewith, and
 that the horizon, or circle which is the
 boundary of light and darkness, and
 which before cut the parallels of lati-
 tude or declination unequally, now bi-
 sects the same, and causes an equal
 distribution of day and night through-
 out the whole. **T E R R E N E**. grid
 itself from henceforward, the youth
 continues the rotation of the globe, he
 will observe, that as many degrees as
 the same pointer advances on the south
 of the equator, just so many degrees
 will the north pole descend below the
 horizon, till it arrives at the tropic of
 capricorn; when the extremity only of
 the arctic circle will appear even, or upon
 a level therewith, and consequently,
 all those countries situate between that
 circle and the pole will then begin to
 lose sight of the sun's body, and whilst
 the inhabitants of the southern pole
 enjoy uninterrupted day, those at the
 northern one are sunk in obscurity
 and twilight.

I have said before that, on the terrestrial globe of this new improvement, the moon moves between the earth and the sun; I shall add now, that at the distance of a quadrant of a circle from the moon, is placed a semi-circle, which being fixed on the centre of the moon's motion always moves round with her, thereby shewing throughout her course, all those countries in the northern hemisphere, to which she is at any particular time rising, those where she is then setting, and those to whom she is then due south, as also the exact difference of time between the rising or setting of the sun and moon; all which will be further enlarged on, when I come to shew the method of solving the problems relating thereto, after I have spoken a little concerning the celestial globe, which is mounted not quite so different from the common globes as that I have been speaking of.

The horizon in this, is as usual, and the globe moveable, to the latitude
of

of any country, only instead of those upright pillars to support the horizon, as common, here semi-circles are fixed on the pedestal, and from the pole of the equator a motion is conveyed to the pole of the ecliptic, where two arms or indices are placed, on which the artificial sun and moon are posited (much after the nature of that excellent contrivance communicated to the Royal Society, in the year 1747, by the ingenious Mr. *James Ferguson*) these, as the globe is turned about, keep their exact motions over the same, similar to and in like manner as those two luminaries do in the heavens, so that being once set right by an ephemeris, they will remain so, and thereby shew the rising and setting of these luminaries, with the length of the day and night, together with the true cause of all the vicissitudes of the seasons, and tho' they have a motion seemingly from east to west, yet do they really move from west to east, the moon in very little more than twenty-nine days
and

and a half, and the sun in a year ; for instance, suppose it to be now the tenth of March, the sun entering Aries, and the moon in conjunction with him ; if I turn about the globe with the key, I shall observe, when the moon has got round to the point Aries, from whence she first set out, which will be in little more than twenty-seven days (which is called her periodical month*) that notwithstanding she has made an intire revolution round the earth, yet will she not be got in conjunction with the sun, because that during the time she is performing this her periodical revolution as a secondary round the earth, that primary, and of course the moon itself its satellite, has advanced almost a whole sign, or thirty degrees in consequentia, or according to the order of

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* The lunar periodical month, or the time the moon takes up in running from any particular fixed point (as a star) in the heavens, till she arrives at the same again, is by astronomers found to be 27 days, 7 hours, 43 minutes, to which if the difference of 2 days, 5 hours 1 minute, and 3 seconds, as above, be added, the sum is her synodical month, or the time between one new moon, or conjunction, and another, viz. 29 days, 12 hours, 44 minutes, and 3 seconds.

the signs in the zodiac; so that, that point in her orbit, in which she was, when in conjunction with the sun, at her first departure, will be now so far to the westward * as to take her up two days, five hours, one minute, and three seconds, before she comes in conjunction with him again, or has completely exhibited all her phases; hence the globe must be turned more than twice about again before the moon can overtake him, which at once affords a very clear idea of the difference between the periodical and synodical month.

Here also may be observed, that the sun's coming above the horizon is very different with respect to time, he rises much sooner and sets much later, and therefore the days of course are longer and the nights shorter in the northern hemisphere; and that with regard to place, he likewise rises and sets in a different

* Here I would not be understood to mean that the orb itself moves (that being only the curve or path in which a planet, as here the moon moves, or describes its revolution round its central body) nor that this supposed point therein moves, it being only a consequence of the earth's annual motion.

different part of the horizon, which difference is called the difference of his amplitude, now rising north-east and setting north-west, whereas before he rose due east and set due west; and if the globe be set to any latitude within the arctic circle, the sun and moon will then move round, without descending below the horizon, at certain times; from whence youth will naturally discern the reasons why these variations thus happen.

I cannot here omit taking notice, how beautifully this method of exhibiting the heavenly appearances, represents those luminaries we have been speaking of, in their apparent motions, to the inhabitants of the polar circles; for instance, if the globe be rectified to the latitude of any country within the arctic circle, by only turning the globe about with your finger you will observe how many days the sun shines upon them without setting, and how many days he is totally absent; as in the former case the sun will continue above
the

the horizon for several revolutions of the globe, so in the latter he will not make his appearance above it for some considerable time; from whence it will be naturally demonstrated, how impossible it is for the inhabitants of that place to have any sight of a new moon during the sun's continuance below the horizon, any more than they will be able to discern a full moon while the sun is above their horizon, as will be shewn when we come to work these problems.



PART



PART II.

PROBLEMS *on the Globes with*
their SOLUTIONS, according to
Mr. Neale's new Improvements of
these Machines.

SECT. I.

PROBLEMS *on the Terrestrial Globe.*

PROBLEM I.

To find the Latitude and Longitude of
any given Place.

SOLUTION.

Find the given place on the globe ;
then turn it to the semicircle which
supports the globe's axis, and on which
the degrees are graduated, and over it
you will observe the number of degrees
it is from the pole, which is the latitude
of the place required ; and by directing
the

* *N.B.* Where this index is affixed, it is to denote that that
Problem differs nothing from common practice in the solution ;
and is only mention'd here to preserve the connexion, and for
the sake of those who have globes mounted after this new
manner, and are unacquainted with the uses of the globes in
common.

the eye to the equator while the globe continues in this situation, observe what degree and minute of a degree, &c. on that line, is cut by the semicircle aforesaid, and that is the true longitude of the place.

PROBLEM II.

The Longitude and Latitude of any Place being given, how to find that Place on the Globe.

SOLUTION.

✚ Bring the given longitude to the semicircle, and under the given latitude mark'd on the same, is the place sought for.

PROBLEM III.

To find the Distance of any two Places on the Globe, in English Miles.

SOLUTION.

✚ This will admit of three varieties.

I. If

I. If the given places are both on the same parallel of latitude, that is, lie east and west from one another.

SOLUTION.

Tell the number of degrees in easting or westing, between the two given places, by bringing them to the semi-circle aforesaid; and observing what degrees on the equator are cut by it, and the number of degrees thus intercepted between the said two places, carried to the table of decreasing longitude, Part I, page 18, and multiplying the quantity of a degree of longitude in that particular parallel of latitude, by the number of degrees found between the two given places, gives the solution in geographical miles, 60 to a degree; which geographical miles multiplied by $69\frac{1}{2}$, and the product divided by 60; or otherwise multiply the said geographical miles by 1.1584 gives the distance in English miles between the places given.

II. If

no. II. If the given places are on the same meridian, that is, lie north and south from one another.

SOLUTION.

Multiply the number of degrees of latitude between them, by $69\frac{1}{2}$ (the number of English miles in one degree) the product is the number of English miles required.

III. If they differ both in latitude and longitude.

SOLUTION.

Then bring one place to the semicircle, and over it fix the quadrant of altitude, and laying it over the other place, count the number of degrees contain'd on the quadrant between them; which number multiply as aforesaid, by $69\frac{1}{2}$, and you have the distance sought.

PROBLEM IV.

To rectify the Globe according to the Latitude of any given Place.

SOLUTION.

On the terrestrial globe of this new improvement,

improvement, no such thing as this is necessary; nor indeed can the globe itself be altered to any other position than that it is mounted to and fixed in, there being no latitude but what it is equally adapted to, and fitted for. But for the greater conveniency of working a variety of curious problems, there is a brass horizon placed in the equator, and so contrived as to move either backward or forward, to the east or west, and with equal facility upwards or downwards to north and south, by which means it may, with great ease, be made to represent the true horizon of any particular country. Therefore instead of rectifying the globe, as in the common method, we must rectify the horizon in this, so as that the given place shall be in the zenith of the said horizon, which must be done in the following manner.

Bring the given place to the semi-circle in which the globe is hung, and on which the degrees of latitude are marked the same as on the meridians

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in the common way, then observe what degree is over the given place; this done, move the aforesaid horizon till the meridian mark* thereon co-incides with the semi-circle, then observe that if the given place is in the northern hemisphere, the horizon must be turned to the southern an equal number of degrees as the given place is from the pole, or in other words, as is the complement of the latitude of the place; but if the given place be in the southern hemisphere, then, instead of depressing the horizon, it must be elevated a like number of degrees in the northern hemisphere.

PROB-

* By the meridian mark on the horizon, is meant the point of the compass due south, to distinguish which from the other cardinal points, it has the face of the sun engraved on the same line with it; and is called the meridian, because when the horizon is thus rectified, as the globe is turned about by the winch, when this meridian mark arrives to such a position, as that a line drawn from pole to pole, so as to pass through the vertical ray (represented here by the pointer) from the sun, cuts the center of this mark, then is the sun in the meridian of the said given place, that is to say, it is then noon day at the said place.

PROBLEM V.

*To find the Sun's Place in the
Ecliptic.*

SOLUTION.

Observe by the annual circle * what degree of any sign is opposite the day of the month on which the solution is to be made, and you will have it without any farther trouble; but this is not finding of it upon the principle of nature; in order to do which, you must put the pointer, representing the vertical ray from the sun, as near as conveniently you can to the globe, so as not to touch it; then turn the globe by the winch, and you will observe the pointer ** cut the ecliptic line in two places, except it prove to be on the

* What is meant by the annual circle is, a circle which is placed on the inside of the solar horizon, and by an index which turns with the annual motion of the globe, is pointed out the day of the month and sun's place, &c.—*Note*, The said index is called the annual index, to distinguish it from the horary or hour index.

** For what is meant by the pointer, see age 51.

the summer or winter solstice; if then the given day of the month, or the day when this solution is to be performed, happens to be between the vernal equinox^a and the summer solstice,^b then the point in the line cut as aforesaid between the equinoctial line and the tropic of cancer, in its ascension towards the latter, is the sun's place for that day; but if the given day be after the summer solstice, and before the autumnal equinox,^c then the point cut in the descending part of the ecliptic, or between the tropic of cancer and the autumnal equinox, is the true place; in like manner, if the given day be between the last mention'd equinox and the winter solstice,^d or between the winter

^a By vernal equinox is understood that particular time when the sun is at an equal distance from pole to pole, or in other words, vertical to the equinoctial line in its apparent passage from the winter to the summer solstice, which happens on the $\frac{21}{22}$ March.

^b For summer solstice or tropic of cancer, see page 12.

^c Autumnal equinox is when the sun by his apparent motion arrives again to the equinoctial line in his passage back from the summer to the winter solstice, which happens on the $\frac{22}{23}$ September.

^d For winter solstice or tropic of capricorn, see pages 13, 14, 15.

winter solstice and the first mention'd equinox, the aforesaid observations attended to will be an infallible guide.*

PROBLEM VI.

A Place being given, to find all those Places which have the same Hour with the given Place.

SOLUTION.

Put the pointer through the sun to the globe, and observe what countries are on the same line with it towards either pole, and the places required are found.

PROBLEM VII.

The Hour of the Day being given in the Place where you are, to find what Hour of the Day it is at any other Place.

SOLU-

* N.B. For the amusement of those gentlemen or ladies who would willingly observe the shiftings of the sun's place throughout the year in the manner before described, without the tedious task of waiting while the globe is turned by the winch 365 times about, there is a spring and button fixed near the south pole, by moving of which the annual is separated from the diurnal motion; by means whereof, in the case aforesaid, satisfaction may be obtained immediately, after which the two motions may be again connected by a single touch.

SOLUTION.

Bring the given place opposite to the pointer through the sun, let the horary index to the given hour, then turn the place required till it also comes opposite to the same pointer, and the index shews the hour at that place.

PROBLEM VIII.

A Place being given, to find all those Places on the Globe which have their Days and Nights of the same Length.

SOLUTION.

Bring the given place to the semi-circle, and observe the degree it passes under, continue the rotation of the globe (by the winch) and observe all those countries which pass under the same degree, for they are the places sought.

PROB-

PROBLEM IX.

The Day of the Month being given, to find those Places in the Torrid Zone to which the Sun will be vertical on the given Day.

SOLUTION.

Turn the globe with the winch till the annual index comes opposite the given day of the month, then by putting the pointer through the sun, and observing all those countries which roll under the same, you have the places required.

PROBLEM X.

The Hour of the Day being given in any Place where you are, to find that particular Place in the Torrid Zone, to which the Sun is at that Time vertical.

SOLUTION.

Turn the globe till the place where you are comes directly against the pointer, then set the hour index to 12 o'clock,

12 o'clock, and by turning it forward to the given hour, the place then under the pointer is that sought for.

PROBLEM XI.

*A Place being given in the Torrid Zone, to find those Days on which the Sun will be vertical thereto.**

SOLUTION.

Turn the globe till the given place comes directly under the pointer, then observe the day of the month the annual index points to, and as the same thing happens twice in the year to the inhabitants of this zone, continue to turn the globe till the given place comes a second time under the pointer, and note the day of the month again, for those are the days required.

PROB-

* This problem is the same as problem IX inverted; that gives the day to find the places, this gives a place to find the days.

PROBLEM XII.

Suppose it to be now Noon-Day in any given Place, in the East or West-Indies; how to find the true Time of the Day at that Instant in London, thereby.

SOLUTION.

Bring the given place to the semicircle, then turn the moveable horizon, 'till twelve o'clock (or the sun's meridian mark) co-incides with it likewise; afterwards turn the globe 'till London comes to the semicircle as aforesaid, and the hour of the day on the equinoctial circle, * which then co-incides with the said semicircle, is the time required.

L PROB-

* By the equinoctial circle, is meant a circle surrounding the globe over the equinoctial line; to which the moveable horizon is hung by two points, and which always turns round with it, &c.—*Note.* This problem is of the same nature with Prob. VI, and as this may be worked according to the directions there given, by the hour index, so may that likewise be work'd according to the directions here given by the equinoctial circle.

PROBLEM XIII.

The Day, and Hour of the Day being given; to find all those Places of the Earth, that are within the enlighten'd Hemisphere.

SOLUTION.

Turn the globe 'till the given day of the month comes opposite to the index; then bring the place where you are, to the sun's meridian, and setting the index to twelve o'clock, turn the globe about 'till the index arrive at the given hour; and all those places above the solar horizon * are the places required.

P R O B -

* By the solar horizon is to be understood, that great circle, which supports the whole machinery; and is distinguished from the moveable horizon, by shewing at all times the whole enlighten'd hemisphere of the globe itself; whereas the other, when rectified to any particular place, respects that place only; consequently may subject at certain times the greatest part of the enlighten'd hemisphere, within this solar horizon, to be beneath the said moveable horizon (of which a certain given place may be the zenith.)

PROBLEM XIV.

*The Day and Hour being given;
to find all those Countries on the
Globe, to which the Sun is then
rising and setting.*

SOLUTION.

Work in all respects as in the last, which done, observe all those countries on the western part of the solar horizon; for to them the sun will appear just rising in the east; then observe all those countries on the eastern part of the said horizon; for to them the sun will appear setting in the west.

PROBLEM XV.

*The Day and Hour being given;
to find all those Places on the
Globe, where it is at that Instant
Noon, and those to which it is
then Midnight.*

SOLU-

SOLUTION.

The globe continued in the same position as the last; a line drawn from pole to pole under the pointer, will shew all the countries where it is then noon day; and those on the opposite side are the places where it is midnight, as may be observed by turning the globe just 12 hours more.

PROBLEM XVI.

A Place being given in one of the Frigid Zones; to find when the Sun begins his Departure therefrom, or to set without rising.

SOLUTION.

Observe, when the given place by the rotation of the globe, at its greatest extremity, comes even with the horizon and not in the least above it, what day of the month is under the annual index, for that is the day required.

PROB-

PROBLEM XVII.

A Place being given in the Frigid Zone; to find on what Day the Sun begins to shine thereon without setting.

SOLUTION.

Observe as you turn the globe the day of the month when the given place, at its greatest declination, exactly co-incides with the horizon, for that is the day the sun begins to shine on them without setting.

PROBLEM XVIII.

A Place being given in the Frigid Zone; to find how many Days the Sun shines upon it without setting, and how long he is totally absent therefrom.

SOLUTION.

Observe the day of the month opposite the annual index at the time the

the given place co-incides * with the solar horizon, and continue the rotation

* Here it is to be noted, that all places situated within the frigid zone, are at certain seasons more or less depressed below the solar horizon (or enlightened hemisphere) this happens to be the case to any particular spot therein, every time the globe is so situated by its annual motion as that the said place shall happen to be more than 90 degrees latitude from those places to which the sun is at that time vertical, so that whenever any given place is thus circumstanced it will appear, according to this new improvement, incapable (notwithstanding the rotation of the globe upon its own axis) of approaching within the solar horizon, but so soon as it arrives within the 90 degrees aforesaid, it will by this method of mounting then appear at its greatest extremity towards the sun, just to rear itself upon a level with the aforesaid horizon; which the reader is desired to take notice is not the thing to be understood by its co-inciding with the solar horizon, in the case before us, but instead thereof, the practitioner is desired to continue the rotation of the globe till the given place shall raise itself higher and higher above the said horizon, 'till by and by he with pleasure observes, that it advances within such a number of degrees to the vertical ray, as that when it is on the opposite meridian it is (even then) no more than 90 degrees from it; consequently when in this situation, it goes no lower than on a level with the horizon, this then is that very situation which is to be understood by the co-inciding in this place. But in order to illustrate the solution of this problem more fully, it may not be amiss to remind the reader (after having obtained a competent knowledge of the true cause of the mutations of the seasons, observed from the aforesaid directions to spring from the annual motion of the earth) that by the celestial globe of this new improvement, he may confirm his knowledge by entertaining himself or friends in working the same solution by the apparent annual motion of the sun, which must be done in the following manner: Elevate the pole to the latitude of the place, then turn about the globe till the sun descends no lower than even or on a level with the horizon, count the number of rotations while it continues above the horizon, for that is the number of days it shines without setting, then continue its rotation till it is got so far below

tion of the globe 'till it co-incides in the like manner therewith again, for that is the number of days it shines without setting; then observe the number of days it remains without making the least appearance above the horizon, for they are those during which he is totally absent.

PROBLEM XIX.

To find the Length of the longest and shortest Day to any Country on the Globe.

SOLUTION.

Turn the globe till the north-pole is at its greatest inclination towards the sun, then observe the time when the given country appears even with the western part of the solar horizon, and

below it as to make its appearance only on a level with it, and count the number of rotations while it remains below the horizon 'till it comes to a level, or co-incides with it again, for they are the number of days (as will self-evidently appear) it remains without rising, or is totally absent, from its inability of raising itself above the horizon.

and observe by the index the number of hours it takes in rolling round to the opposite or eastern part thereof, for that is the length of the longest day, if in the northern hemisphere, and of the shortest if it be in the southern; and *vice versa*, if you continue the rotation of the globe till the south pole arrives at its greatest inclination towards the sun (for then the north pole will be at its least inclination thereto) those in the northern hemisphere must have their days at the shortest.

PROBLEM XX.

The Place and Day being given; to find at what Hour the Sun rises and sets, and the Length of the Day and Night.

SOLUTION.

Turn the globe till the annual index points to the day of the month and the given place comes opposite the sun, set

set the hour index to 12, then turn the globe 'till the given place comes to the opposite part of the horizon, and it shews its setting, and the number of hours between the time of rising and setting gives the length of the day in that place, and the time the said place is below the horizon shews the length of the night.

PROBLEM XXI.

How to find those Countries within the Temperate Zone who have the greatest Degree of Twilight.

SOLUTION.

By turning the globe about, it will be observed that the greater distance they are from the sun's vertical rays falling on them in any country, by so much more of twilight do they enjoy at certain seasons, as may be observed by comparing our own situation in the latitude of 51° with any of those

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within

within the tropicks; whence it will appear we enjoy much more than they, while those in the latitude of 65, 66, &c. have as much more in proportion than we; as may be more fully understood by a due attention to the solution of the following problem XXII. &c.

PROBLEM XXII.

To find the Length or Continuance of the Morning and Evening Twilight in any given Place.

SOLUTION.

There are two ways also in working this: first, observe the time by the index when the given place comes within 18 degrees of the solar horizon, and again note the time when it makes its appearance on the said horizon for that is the length of the morning twilight; then observe the time it co-incides with the horizon on the opposite side till its arrival 18 degrees below it, for that is the length of the evening

evening twilight: secondly, by rectifying the brazen horizon to the latitude, according to directions in pages 65, 66, observe when the pointer arrives within 18 degrees of the horizon how long it is before it co-incides with it, for that is the length of the morning twilight; then observe the difference of time from its co-inciding with the horizon on the opposite side till the same is depressed 18 degrees below it, for that is the length of the evening twilight: the reader will observe that in the former case, the given place is looked for so much below the solar horizon; and in the latter, the horizon of the given place shews the pointer from the sun to be so much below it. *

PROBLEM XXIII.

How to shew the Time when the Moon rises and sets for every Day in the Year to any given Place.

* The way to illustrate this on the celestial globe by the apparent motion of the sun is self-evident, by counting the number of hours the sun itself takes in advancing the said 18 degrees below the horizon as the said globe is turned about.

SOLUTION.

The moon's place once rectified by an ephemeris, and the horary index set right accordingly, when the said place co-incides with the moon's horizon in the west, the index will point out the time of her rising, and when it arrives to the said horizon in the east, it will then in like manner point out the time the moon will be apparently setting in the west.

PROBLEM XXIV.

To demonstrate how much the Moon rises and sets before or after the Sun every Day in the Year in any given Place.

SOLUTION.

Bring the given place to the lunar * horizon, on the western side, and count

* What is meant by the lunar or moon's horizon is a semi-circle at 90 degrees distance from the moon, and moves round with it, which represents the horizon of that luminary for the northern hemisphere.

count the number of hours by the index before it arrives to the solar horizon, and it gives the time the moon rises before him; in like manner when the given place comes to the moon's horizon on the eastern side, the number of hours before its arrival at the sun's horizon is the time it sets before him, and *vice versa* when it happens to be after the sun, to count from the solar to the lunar horizon.

PROBLEM XXV.

*The Cause of an Eclipse of the Sun,
how to demonstrate it.*

SOLUTION.

This is self evident on either globe,
by turning them by the winch 'till the
two

The method of working this problem on the celestial globe from the apparent motion of the luminaries is only to observe by the index, the time the first of the two rises even with the horizon, then by continuing the rotation of the globe, when the following co-incides in like manner, the index shews the difference; and the same thing must be observed for their setting.

two luminaries arrive in conjunction with each other, provided they happen to be in or near the nodes *

PROBLEM XXVI.

To demonstrate the Cause of an Eclipse of the Moon.

SOLUTION.

This is no less evident than the former, by turning either globe with the winch, 'till the two luminaries come in opposition to each other.

PROBLEM XXVII.

To explain the Reason why they happen no oftner.

SOLU.

* Nodes are points of intersection of the sun's orbit or of any planet with the ecliptic, so that the point where a planet passes over the ecliptic out of south into north latitude, is called the north node; and that point where it descends from or crosses the ecliptic out of northern into southern latitude, is called the south node.



SOLUTION.

This is as evident as either of the former; by setting the moon to any considerable latitude, and putting the pointer through the sun when the moon comes in conjunction therewith, it will be seen to pass either above or below it, according as it is in north or south latitude, * manifestly shewing how impossible it is for an eclipse to happen at any other time than when the moon is either in or near her nodes.

PROBLEM XXVIII.

How to exhibit a natural Representation of the Motion of the Moon's Nodes.

SOLU-

* In order to shew the latitude of the moon more exactly, a small dot is made in the centre of the moon's hemisphere towards the sun, which if the moon be in the nodes will be exactly on the same line with the pointer, consequently would intercept the rays of the sun from reaching that particular spot of our globe it would otherwise enlighten; if therefore the globe be turned, till the moon comes once more about or again in conjunction, that same spot will be then observed to be either above or below the said pointer, in which case no such eclipse could happen.

SOLUTION.

This is done by only turning the globe with the winch, and observing that the place where the moon crosses the ecliptic, in its motion round the earth, is every time in different places.

PROBLEM XXIX.

How to demonstrate the aforesaid Motion of the Nodes to be retrograde or contrary to the Order of the Signs.

SOLUTION.

This is done by continuing the rotation of the globe as aforesaid, and observing that the places of the ecliptic where the moon crosses, (which are the nodes) recede from east to west, or backward thro' all the signs.

PROBLEM XXX.

How to demonstrate what Number of Years the Moon's Nodes require before they make one complete retrograde Revolution.

SOLU.

SOLUTION.

This is done by counting the number of annual revolutions of the globe while the nodes move from any fixed point to the same again.

PROBLEM XXXI.

How to demonstrate the Reason why, notwithstanding the Moon moves round the Earth in a little more than 27 Days, it is full 29½ before it gets from one Conjunction with the Sun to another.

SOLUTION.

Let the globe be turned about till it comes into such a position, as that the semi-circle in which the globe is hung as also the moon come in conjunction with the sun, then turn the globe a little more than 27 times, and you will find it in conjunction with the semi-circle as before, but not so with the

N sun,

sun, for the globe must be turned more than twice about before that can be produced; the reason of this see on pages 57, 58. *

PROBLEM XXXII.

To represent the several Phases of the Moon, and shew the true Cause of that Variation.

SOLUTION.

By turning about the globe the moon always keeping the enlightned part towards the sun, naturally exhibits the several phases beheld by us, together with the true cause thereof.

PROB-

* To work this on the celestial globe, observe what fixed star the moon is in conjunction with, at the same time it is in conjunction with the sun; then turn about the globe till it is in like manner in conjunction with the said star again, and you will find a little more than 27 turns will do; but that it must be full 29 $\frac{1}{2}$ before it comes in conjunction with the sun.

Note, By working this on the terrestrial, the globe during the process moves near a 12th part of her annual course; but by working it on the celestial, the sun during the process apparently moves in the same proportion.

PROBLEM XXXIII.

How to exhibit a Representation of the Moon's Motion once round on its own Axis while it is going once round the Earth.

SOLUTION.

This is done by observing any particular spot in the moon's body, and observing that when the moon has made one compleat revolution in her orbit, the same spot will likewise have made a compleat revolution round her axis.

PROBLEM XXXIV.

The Day and Hour of the Day being given when a Solar Eclipse will happen, to find all those Places on the Globe to which the same will be visible.

SOLU-

SOLUTION.

Turn the globe till the given day comes opposite the sun, and the place where you are, to the pointer, set the index to 12, then turn the globe till the index points to the given hour, set the moon in conjunction with the sun, and all the places above the solar horizon are those to which the eclipse will be visible.

PROBLEM XXXV.

The Day and Hour of the Day being given when a Lunar Eclipse will happen, to find all those Places on the Globe to which the same will be visible.

SOLUTION.

Proceed as in the last problem, only instead of the moon's being in conjunction, it must now be in opposition

to

to the sun, and instead of viewing all the countries on that side the horizon towards the sun, you must survey those on the opposite side, for they are the countries to which the same will be visible.

PROBLEM XXXVI.

To explain the true Cause of the Moon's rising and setting every Day at such a Distance of Time from the preceding one.

SOLUTION.

Observe the time by the hour index when any given place co-incides with the lunar horizon, * and turn about the globe till the said place co-incides with the horizon again (or on the day following) you will observe that by the moon's motion in her orbit the said horizon

* To illustrate this on the celestial globe, the moon's motion causing it to come to the horizon at different times, confirms the aforesaid observation, that, from the apparent, as this is from the real motion.

rizon is moved, which causes the difference of time observed by the index, before it co-incides with it as before in the preceding day.

PROBLEM XXXVII.

To exhibit the Nature of the Harvest Moon, shewing the true Cause why the Moon then rises several Days together within a small Space of Time of what she did on the preceding Day, contrary to what she does at any other Time of the Year.

SOLUTION.

This curious problem is solved by setting the moveable horizon to the latitude of the place, and the meridian thereof to the meridian of the said place, then turn about the globe till the moon rises in Aries, and the time of her rising 3 or 4 days before her full, compared with several days after, will shew you, not only that there is but a little difference between one day and another, in comparison

parison to what happens at other seasons of the year, but also the natural occasion of it, as will appear self-evident from the bare working the problem itself.*

PROBLEM XXXVIII.

How to demonstrate that the Moon is nearer to the Sun by near half a Million of Miles when she appears as a New Moon, than she is when she

* In order to explain this phenomenon of the harvest moon to those who have not any globes to work the problem, we need only consider that when the sun is in the beginning of Aries, the full moon on that day must be in the beginning of Libra, and since when the sun sets, or moon rises on that day, those equinoctial points will be in the horizon, and the ecliptic then will be least inclined thereto, the part or arch which the moon describes in one day, viz. 13 degrees, will take up about an hour and a quarter ascending above the horizon, and therefore so long will be the time after sun-set the next night before the moon will rise. But at the opposite time of the year, when the sun is in the autumnal, and full moon in the vernal equinox, the ecliptic will, when the sun is setting, have the greatest inclination to the horizon, and therefore 13 degrees will, in this case, soon ascend, viz. in about a quarter of an hour, and so long after sun-set will the moon rise the next day after the full: whence at this time of the year, there is much more moon light than in the spring, and hence this autumnal full moon came to be called the harvest moon, the hunter's or shepherd's moon. (See Martin's Philos. Brit.)

She appears as a Full Moon, allowing the Orbit to be at 240,000 Miles from the Earth's Centre.

SOLUTION.

This problem is solved by only turning the globe 'till the moon goes from the new to the full, or from the full to the new, and will answer itself by its own very great difference of distance between the two stations.

PROBLEM XXXIX.

How to shew the Sun's Amplitude for any given Day of the Month.

SOLUTION.

Set the moveable horizon to the latitude of the place, then turn the globe till the annual index points to the given day of the month, and observe the point of the compass directly opposite the sun's pointer at the time the laid horizon by the rotation of

of the globe arrives even with the said pointer in the morning, for that is the amplitude for rising, and turn to the evening, or opposite western point of the horizon, and you have it for the setting.

PROBLEM XL.

How to demonstrate that the Inhabitants under the Equinoctial Line enjoy two Summers and two Winters every Year.

SOLUTION.

This will appear self-evident by turning the globe once about in its annual orbit; for instance, suppose the sun now to be over them, the pointer will be in the equinox, it is then their summer; after this, three months brings its appearance to the tropic of Cancer, and this being as far as it can go from them, it will be their winter, turn three months more and it brings it to what we call autumnal equinox, which, to them, is equally summer
O again,

again, and in three months more, appearing in the tropic of Capricorn, (which is our winter) it is with them winter again; thus have they summer and winter twice, while the earth is going round the sun once.

PROBLEM XLI.

How to demonstrate that the Moon can never appear as the Full Moon during the Summer Half-Year to the Inhabitants of the North Pole.

SOLUTION.

This will appear self-evident by turning the globe till the moveable horizon, set to the latitude of the place, arrives to such a situation, with respect to the pointer from the sun, as that no part shall be below it, because then the moon at full, being in opposition, must and will, as appears from inspection, be necessarily below it, and consequently unseen.

PROB-

PROBLEM XLII.

How to demonstrate that the Moon cannot be seen as a New Moon during the Winter Half-Year to the said Inhabitants.

SOLUTION.

This will appear no less evident than the former, by observing when the pointer from the sun is unable to rear itself above the horizon, the moon (if in conjunction) must be below it also, therefore it can never be seen as a new moon.

PROBLEM XLIII.

How to represent the Countries to which the Sun rises and sets within the Compass of the same Hour at certain Seasons.

SOLUTION.

It is only turning the globe about with the winch, 'till the pointer is 23 hours below the moveable horizon, when rectified to the latitude of particular places within the arctic circle.

P R O.

PROBLEM XLIV.

How to demonstrate that to certain Inhabitants of our Globe the Sun will set near half a Year together within a Trifle of the same Hour of Time, but in the interim differ above 20 Degrees with Respect to its Amplitude.

SOLUTION.

Set the moveable horizon as near as possible to the poles, the zenith of which will then be equally near the equinoctial line ; and then compare the points of the compass it sets on with the time (by the index) on which it sets, you then have the solution.

PROBLEM XLV.

How to find the Sun's Altitude for any given Time on any Day throughout the Year in any given Place.

SOLUTION.

Set the moveable horizon to the latitude of the place, and turn the globe

globe 'till the annual index points to the day of the month, then observe when the horary index [being first rectified to 12 at noon] points to the given time, and by moving the quadrant of altitude to the pointer it gives the sun's altitude by the degrees pointed to that are engraved thereon.

PROBLEM XLVI.

How to find his Meridian Altitude on any given Day.

SOLUTION.

Proceed as before, only let the quadrant of altitude be fix'd due south, and when it arrives to the pointer on the given day it will give the solution.

PROBLEM XLVII.

How to determine the variation of the Needle by a Globe thus moun- on any part of the Sea by one Observation only, suppose the Latitude known.

SOL-

SOLUTION.

Rectifie the moveable horizon to the latitude of the place. Turn the globe till the day of the month comes opposite the pointer, then turn the meridian to the said pointer, and set the hour index to twelve. Thus prepared, keep the quadrant of altitude by the figure directly opposite the pointer while the globe is turn'd by the winch, till the degree of the sun's altitude taken by an observation, exactly coincides with the said pointer, then turn your eye to the foot of the quadrant, and the degree on the horizon on which it rest's, shews the true bearing of the sun, which compared with the magnet on board, will directly discover the exact variation of the Needle, and consequently will be a proper standard by which to correct errors, while the hour index points out the true time of the day.

PROBLEM XLVIII.

How to shew the Sun's Azimuth at any given Time by the Globe.

S O L U.

SOLUTION.

Proceed as in problem XLVI, only instead of observing the degrees on the quadrant of altitude, on its approach to the pointer, you must now observe the degree and minutes or point of the compass on the moveable horizon, which is just at the foot of the said quadrant.

PROBLEM XLIX.

How to find the Hour of the Day by the Sun's Azimuth.

SOLUTION.

Proceed as before, and opposite the azimuth will be found engraved on the moveable equinoctial circle * the time of the day.

PRO.

* What is meant by the moveable equinoctial circle is that to which the moveable horizon is hung by two points, and always turns with it.

PROBLEM L.

How to find the Sun's Altitude by his Azimuth.

SOLUTION.

Proceed as before, then bring the quadrant of altitude to cut the azimuth, and the pointer will direct to the thing sought for.

PROBLEM LI.

How to find the Time of the Day by the Sun's Altitude.

SOLUTION.

Proceed as in problem XLVI, 'till the pointer arrives to the given altitude, and the hour index will shew the time of the day.

PROBLEM LII.

How to find the Sun's Depression below the Horizon at any given Time of the Night.

SOLU.

SOLUTION.

The aforesaid direction attended to, will leave nothing more to be done, in order to the solution of this, than only continuing the rotation of the globe till the hour index points to the given time, then the pointer will shew how much the sun at that time, is depressed below the horizon.

PROBLEM LIH.

How to shew those Countries to which the Sun appears to them either rising or setting, within a few Minutes of the same Time, for several Days together at a certain Time of the Year.

SOLUTION.

Set the moveable horizon to the latitude of 66 and half, then turn about the globe, till it rises so as to cause the sun to appear in Cancer, then when the index points to the same hour, the pointer from the sun will for several Days coincide with the said horizon, or at least within a few minutes of the said time. PROB.

P R O B L E M L I V.

How to demonstrate that to the People of a certain Latitude the Sun goes apparently backwards and forwards with regard to the Azimuth, twice in one Day, at a certain Season of the Year, without derogating from the miraculos going back of the Shadow mentioned in the Sacred Writings.

Set the moveable horizon to the latitude of a place within the tropic, suppose Barbadoes, about 13 degrees north latitude, then set the quadrant of altitude, that the foot thereof may be about 2 degrees south of the sun or pointer at its rising, then by turning the globe about the solution will appear conspicuous. But it is to be observed that this is most so, when the sun is in or near the tropic of Cancer.

P R O B -

N. B. In the following Problem 55, instead of the above said, read to certain Inhabitants, and in the Solution, instead of continuing the Globe, as in the last, read rectify the Globe to 66 and half, then turn it till, &c.

PROBLEM LV.

How to demonstrate that to the afore-said Inhabitants there is a certain Day in the Year to which the Sun is almost the whole 24 Hours absent from them, and in the few remaining Minutes, only makes his Appearance just on a Level with the Horizon and then sinks again as before.

SOLUTION.

Continue the globe as in the last, 'till the pointer arrives to Capricorn, and then it will be self-evident that the highest pitch the said pointer can reach, is only to come on a level with the said horizon.

PROBLEM LVI.

How to shew the Sun's right Ascension for any Day in the Year.

SOLU-

SOLUTION.

The moveable horizon first rectified according to the directions before given, turn the globe 'till the annual index points to the given day of the month; then turn the given place to noon, and the pointer will shew the sun's right ascension* engraved on the moveable horizon aforelaid.

PROBLEM LVII.

How to shew the Sun's Declination.

SOLUTION.

Proceed as before, only instead of observing the degrees on the horizon for the right ascension, you must now bring the quadrant of altitude to the pointer, and the degree pointed to thereon is the declination** of the sun for that day.

P. R. Q. B.

* For right ascension, see article VIII. page 47.

** For declination, see article I. page 44.

PROBLEM LVIII.

The Day of the Month and Time of the Day known, how to find by the Globe the Latitude of the Place by the Sun's Meridian Altitude.

SOLUTION.

Turn the globe 'till the annual index points to the day of the month given, and set the quadrant of altitude to the given altitude at noon, on the given day; then turn the globe 'till the quadrant aforesaid co-incides with the semi-circle which supports the globe, and the degree graduated thereon, cut by the horizon, is the latitude of the said place.

PROBLEM LIX.

The Day of the Month and Time of the Day known, how to find by the Globe, the Latitude of the Place by the Sun's Azimuth any Hour of the Day.

SOLU.

SOLUTION.

Proceed as in the last, only instead of using the quadrant of altitude, as there directed, observe to move the horizon in such a manner as that when the annual index points out the day of the month, and the hour index the hour of the day, the pointer shall direct to the given azimuth* on the horizon, then turn the horizon to the semi-circle aforesaid, and it will point to the latitude of the place required.

PROBLEM LX.

How to find the Latitude of the Place by the Time of the Sun's rising in the Morning.

SOLUTION.

Turn the globe 'till the annual index comes to the day of the month, then turn the moveable horizon 'till the pointer rises at the given time of the morning

* For azimuth, see article VII. page 46.

[III]

morning by the hour index, which must be first rectified according to directions problem XLVI. page 102, after which, turn the said horizon to the semi-circle aforesaid, and the thing sought for will appear manifest.

PROBLEM LXI.

How to find the Latitude of the Place by the Sun's setting on any Day of the Year.

SOLUTION.

Work in all respects as before, only instead of observing when the pointer co-incides with the horizon in the morning, you must now do the like for the evening.

PROBLEM LXII.

How to find the Latitude of the Place by the Sun's Amplitude.

SOLU-

SOLUTION.

Proceed as before till the pointer co-incides with the given amplitude on the horizon, and the said horizon will then point out the latitude of the place on the semi-circle, as in the former examples.

PROBLEM LXIII.

How to find the Time of the Morning or Evening by the Sun's Amplitude at his rising or setting

SOLUTION.

Work as in the two foregoing problems, only have respect to the pointer co-inciding with the given amplitude, and you have the thing sought for.

PROBLEM LXIV.

How to find the Day of the Month on the Globe by the Sun's Meridian Altitude.

SOLU-

* For amplitude, see article VI. page 46.

SOLUTION.

The moveable horizon rectified, only turn the globe 'till the given altitude exactly co-incides with the pointer at noon, and the annual index will then point to the day of the month.

PROBLEM LXV.

How to find the Day of the Month by the Sun's Amplitude at rising or setting.

SOLUTION.

Proceed as before, only have respect to its amplitude, and the aforesaid index will point out the solution.

PROBLEM LXVI.

The Day of the Month and Time of the Day given, to find by the Globe how many Degrees and Minutes a Line drawn from the Zenith of a given Place, cutting the Centre of the Sun, will fall on the Horizon from the Meridian of the said Place.

Q **SOLU-**

SOLUTION.

As this and the three following problems are only intended for the entertainment of those who love the art of dialling, it is only necessary to observe, that when the moveable horizon is rectified, and the globe turned 'till the annual index points to the day of the month, and the hour index to the given hour, then the quadrant of altitude set so as to cut as it were the pointer, the foot of the said quadrant will then shew the thing sought for, by the degrees on the horizon. *

PROBLEM LXVII.

The Day of the Month given, how to find the Difference of the Distance at the Horizon of two Lines drawn from

* It may appear at first view to those who are unskilled in astronomy a little incredible that several lines drawn from the zenith through the center to the horizon at equal portions of time should not themselves be of equal distances from each other, but it is improbable that to such persons the reason of it may be something difficult to conceive. For their sakes therefore are these problems introduced, that they may at one view discern the difference between lines drawn from the zenith to the horizon through the center of the sun in any station, and those drawn from the zenith to the horizon at equal portions of time thro' the meridian of any given place.

from the Zenith of a given Place through the Sun's Centre while on the Meridian, and at one Hour's Distance of Time from his passing the Meridian, compared with two other Lines drawn, one an Hour before the Sun sets, and the other at the Time of his setting.

SOLUTION.

Set the globe in the situation of the former problem, then by turning it one hour from noon and moving the quadrant to the pointer as before, compared with doing the like an hour before the horizon reaches the pointer, the thing sought for will appear self-evident.

PROBLEM LXVIII.

How to shew the Difference of the aforesaid Distances between the Equinoctial and the Horizon of the said Place.

SOLU-

SOLUTION.

Proceed as before, and while you note the degree on the horizon at the foot of the quadrant, observe at the same time the degree cut by the said quadrant on the equinoctial, and you have the thing sought for.

PROBLEM LXIX.

To demonstrate how the Differences of the aforesaid Distances vary according to the Time of the Year.

SOLUTION.

By turning the winch till the globe has passed through theseveral seasons, by the difference of the inclination of its axis with respect to the sun, and comparing the aforesaid solutions in these several positions, not only the thing sought for will be discovered, but also the reason thereof will appear manifest.

SECT. II.

PROBLEMS on the Celestial Globe,
relating to the Sun and Moon.

PROBLEM I.

To rectify the Globe for any given Place.

SOLUTION.

☉ This is done in the same manner as in common practice, by bringing the given place to the brazen meridian, and observing how many degrees of latitude the said place is from the equator; then turn about the meridian till the pole itself be the like number of degrees above the wooden horizon, or

Observe the number of degrees between the given place and the pole, and turn the meridian till the equator gets as many degrees below the wooden horizon.

horizon; in either case the given place is brought into the zenith, which is properly rectifying the globe.

PROBLEM II.

To find the Sun's Place in the Ecliptic.

SOLUTION.

Find the day of the month in the kalendar on the wooden horizon, and opposite thereto in the table of the signs of the zodiac upon the said horizon, is the degree of the ecliptic which the sun is in for that day.

PROBLEM III.

To rectify the Sun and Moon over the Globe according to these Improvements, so that they shall correspond with their like Places in the Heavens.

SOLUTION.

Observe to place the globe due north and south by a compass; or if you have not a compass observe that the north pole points towards the north side of the horizon, or where the month of June is engraved thereon.

SOLUTION.

After having found the sun's place according to the directions given in the foregoing problem, turn the sun about by its stem 'till it arrives directly opposite the same degree and sign of the ecliptic upon the globe, and it will then agree with his place in the heavens; the same may also be done with respect to the moon, having first found her place by an ephemeris * for that day.

PROBLEM IV.

To find the Time of the Sun's rising and setting for every Day in the Year.

SOLUTION.

Rectify the sun to its true place, then bring it to the meridian, and set the index to 12 at noon, this done, turn
about

* Ephemeris, tables which shew the places of the planets every day at noon, &c.

about the globe as many times as you please, the index will point out the time of the sun's rising or setting, by observing when it co-incides with the horizon in the morning and evening, which is the thing sought for.

PROBLEM V.

To find the Time of the Moon's rising or setting for every Day in the Year.

SOLUTION.

The aforesaid directions concerning the sun duly attended to, will in like manner, with respect to the moon, shew her time of rising or setting.

PROBLEM VI.

How to shew the Number of Hours the Sun or Moon appears above the Horizon on any Day of the Year.

SOLU.



SOLUTION.

Proceed as before, and count the time by the index from their respective appearing in the east, to their setting in the western part of the horizon, and you have the thing sought for.

PROBLEM VII.

To shew the Number of Degrees the said Luminaries descend below the Horizon at Midnight, for any Day in the Year.

SOLUTION.

Observe the former directions, and by turning the globe 'till the hour index comes to 12 at night, and counting the degrees • from the horizon to the said luminaries, you will have the solution.

R PROB-

• This must be done by taking the quadrant of altitude and measuring from the upper part of the horizon to the said luminaries.

PROBLEM VIII.

How to shew the Time when the Moon rises and sets to any particular Latitude for any Day in the Year.

SOLUTION.

Set the moon according to the directions in the solution to problem IV. and at the same instant that the sun comes to the meridian set the horary index to 12, then turn the globe as often as you please, and the said index will point out the time of her approach to, and departure from the horizon.

PROBLEM IX.

To demonstrate how much the Moon rises and sets before or after the Sun every Day in the Year, to any given Latitude.

SOLU.

SOLUTION.

For this solution see note* page 85,
under problem XXIV. of the same
nature, on the terrestrial globe.

PROBLEM X.

*The Cause of an Eclipse of the Sun or
Moon, how to demonstrate it.*

SOLUTION.

Turn to page 86 and observe the
solutions to problems XXV. and XXVI.
and you will have the thing sought for.

PROBLEM XI.

*To demonstrate that the Moon is more
than two Days longer in going from
the Sun to her Conjunction or Ar-
rival at the said Luminary again,
than she is in making one compleat
Revolution round our Earth.*

SOLU-

SOLUTION.

See the solution for problem XXXI. on the terrestrial globe, compared with the note, page 90.

PROBLEM XII.

To shew the Nature of the Harvest Moon.

SOLUTION.

Turn about the globe 'till the sun arrives at the autumnal equinox, and then you will find by the index that the moon comes to the horizon for several days together within a short time of each preceding day, contrary to what it does at all other seasons in the year. See the note for problem XXXVII. page 95.

PROBLEM XIII.

To demonstrate that to the People of certain Latitudes, the Moon may be seen in their Horizon either rising or setting within one Hour of the same Time for every Day in the Year.

SOLU-

SOLUTION.

Rectify the globe to the latitude of $66\frac{1}{2}$ degrees, and by turning about the globe you will observe the moon come to the horizon always within the space of an hour of the same time.

PROBLEM XIV.

To demonstrate that to the Inhabitants of London the Moon may rise at a certain Time of the Year 16 Hours before the Sun, and in the Evening of the same Day the Sun will set no more than 8 Hours before the Moon.

SOLUTION.

Rectify the globe to the latitude $51\frac{1}{2}$, then turn it about till the moon enters the tropic of Cancer at the same time the sun enters Capricorn, then you will observe that the moon is rising at the time the sun is setting, and will find by the index, 16 hours before the sun

sun makes its appearance, in which time the moon will be near setting; and in eight hours more, you will find, by continuing the rotation of the globe, the sun to set also.

PROBLEM XV.

To demonstrate that to certain Latitudes the Moon may rise and set 15 Days together within a Trifle of the same Time, yet vary in her Amplitude near one Half of the Compass.

SOLUTION.

Observe the directions in the solution to problem XIII. to which you only need to add the proper notice of the several points of the compass on which the moon rises or sets, and you have the things sought for.

PROB.

PROBLEM XVI.

To demonstrate that to the People of a certain Latitude, it is either Morning or Evening within one Hour of the same Time several Days together at certain Seasons of the Year.

SOLUTION.

Set the globe to the latitude of 66 and half, then by turning it about the thing itself will appear evident from the sun's being in their horizon either rising or setting, nearly at the same time for many days together at particular seasons.

PROBLEM XVII.

To demonstrate that to the Inhabitants of the aforesaid Latitude, at a certain Time of the Year, it is both Morning and Evening within the Compass of the same Hour.

SOLU.

SOLUTION.

The globe rectified as before, observe when the sun arrives near the tropic of Capricorn, and as you turn about the globe, the thing sought for will evidently appear.

PROBLEM XVIII.

To demonstrate that to the aforesaid Inhabitants, there may be at a certain Time of the Year near 24 Hours between Morning and Evening.

SOLUTION.

The last direction relating to the observation of the sun near Capricorn, will now hold good, when it arrives near Cancer.

PROB-

PROBLEM XIX.

To demonstrate that notwithstanding it may be either Morning or Evening within one Hour of the same Time to the Inhabitants of some Parts of the Globe, yet there are certain others to whom there is no less than 12 Hours Difference between the Sun's rising and setting, or setting and rising throughout the Year.

SOLUTION.

In order to work this problem the globe must be taken out of the horizon, and the meridian regarded as the horizon of the inhabitants under the equinoctial-line, to whom it will be observed, there will be equal portions of day and night throughout the year.

PROB.

PROBLEM XX

To discover that particular Latitude to which the Moon will have a larger Extent of Amplitude, than to any other whatsoever.

SOLUTION.

Set the globe to the latitude of 66 and half, and the moon's amplitude for every fifteen days, compared with other latitudes, will be found to exceed them all.

PROBLEM XXI.

How to shew those particular Countries to which the Moon, no less than twice in every Revolution round the Earth, appears to describe a Ring round their Horizon.

SOLUTION.

Continue the globe in the latitude aforelaid, and every time the moon crosses either equinox, the thing sought for is found.

PROB-

PROBLEM XXII.

How to shew the Sun and the new Moon in Conjunction at a certain Hour, each going round the Horizon, when the Moon will be seen running through all the Points of the Compass so much faster than the Sun, that at its Arrival at the End of her Course, the Sun will be no less than 13 Degrees behind her.

SOLUTION.

Rectify the globe to the latitude of 90 degrees, when the pole will be in the zenith; then bring both luminaries to either equinox, and put them in conjunction, observe the point of the compass, and turn about the globe till they have both run fairly round, and you will see more than 13 degrees difference; which is an exact resemblance of what they do in the heavens.

PROB-

PROBLEM XXIII.

To shew, by the Interposition of the Moon's Body, the Occultation of any given fix'd Star within the Zodiac.

SOLUTION.

Turn the globe till the Moon's distance from the equator is the same with the given star, continue to turn it 'till its longitude be also equal, and the thing sought for, will be found.

PROBLEM XXIV.

To find by the Globe the Time of high Water at London-Bridge, on any given Day of the Moon's Age.

SOLUTION.

Turn about the globe till the moon's index points to the given day,

day, and directly under it will be found the Time required. *

PROBLEM XXV.

To demonstrate the Reason of the ebbing and flowing of the Tides, at such Distance of Time from one Day to another.

SOLUTION.

Observe by the index the time it is high water at, either new or full moon, then take notice of any particular spot on the globe opposite the moon; turn the globe about once, and you will perceive that that very place or spot falls so much short of being again in opposition to the moon, as will take almost one Hour in time by the index, before it gets up

* This is on a supposition that the index plate is engraved for London, which is not always the case; as they may with equal ease be done for any given place the globes are bespoke for.

up with it; the reason whereof will evidently appear to spring from the moon having shifted her place in the heavens full 13 degrees forward; as therefore the waters in their course are attracted by, they must manifestly attend the moon, and the same reason for the moon's difference of situation at the end of every twenty-four hours, will invariably hold good with regard to the time of high water.

PROBLEM XXVI.

How to find the Time of the Night by the Altitude of the Moon.

SOLUTION.

The globe rectified to the latitude of the place, put the moon to her true place by an ephemeris, and rectify the index to it; then turn the globe till the moon arrives above the horizon, at the given altitude,

altitude, * and the index will point out the time of the night.

PROBLEM XXVII.

To shew the Time of the Night by the Azimuth of the Moon.

SOLUTION.

Proceed as before, only instead of fixing the quadrant in the zenith, screw it on the meridian altitude of the moon for that time; then lay it across the globe to the degree on the horizon the moon is observed to rise on, and when done, turn the globe 'till the moon arrives to the given azimuth engraved on the said quadrant of altitude, and then the index will readily point out the time of the night.

PROB-

* This must be done by fixing the quadrant of altitude to the zenith of the place, and turning it to the moon, there the thing sought for.

PROBLEM XXVIII.

To shew by the Globe the Time of the Night by the Moon's rising.

SOLUTION.

The globe, the moon, and the index rectified according to the afore-said directions, nothing more is needful, than only to observe by the index the time the moon coincides with the horizon at her rising.

PROBLEM XXIX.

How to demonstrate that the Moon moves slower than the Earth in her Annual Orbit, from the Beginning of the last, to the End of the first Quarter.

SOLUTION.

Observe while you turn the winch, that at the end of every revolution

of the globe after the moon enters the last quarter, she actually is more and more towards the west than on the preceding day; consequently as the earth moves every day nearly through one degree of space in its course round the sun, the moon must fall short of moving through an equal degree of space in the said circuit, by just the quantity she is from day to day found more westerly than on the preceding day.

PROBLEM XXX.

How to demonstrate that from the End of the first Quarter, to the Beginning of the last, the Moon moves faster than the Earth in her Yearly Course.

SOLUTION.

The globe turn'd by the winch, you will find, at the end of every revolution, the moon will be considerably more eastward than on the preceding
T day;

day; and as the earth keeps advancing from the west towards the east, the moon gains as much in proportion in this case, as it lost in the former.

PROBLEM XXXI.

To demonstrate, that if the Earth was in a State of Rest, the Moon would appear to an Eye from the Sun to move retrograde one half of her Course round the Earth, or 15 Days out of every Month.

SOLUTION.

This appears manifest by the spectator's placing his eye near the artificial sun, while the operator turns the globe about; he will then see that during the progress of the moon through the second and third quarters, she moves according to the order of the signs from west to east; but from her entrance into her last, to the end of her first quarter, moves

moves the contrary way, but to an eye from the earth she moves regular. *

PROBLEM XXXII.

The Reason why the Moon can never be seen at the North-pole, during the Summer half Year, as a full Moon; or as a new Moon during the Winter half Year.

SOLUTION.

The globe rectified to the latitude of the pole; by bringing the pole into the zenith, only turn it about till the luminaries are in opposition while

* When we say the moon moves regular, it must be understood not absolutely an equable motion at all times, and through all parts of her course; there are several reasons why it cannot in the nature of things be so: To mention but two, her moving quicker in her Perigæum ^a than in her Apogæum, ^b on account of the elliptical figure of the lunar orbit; the continual varying of the excentricity ^c of the moon's orbit, which must unquestionably produce an inequality of her apparent motion.

^a Perigæum, is that point wherein a planet is at its nearest distance from the earth, as,

^b Apogæum, is the greatest distance that any planet can possibly be therefrom.

^c Excentricity, is the distance of the centre of a planet's orbit from the sun.

while the sun is above the horizon, the summer part of the problem will be immediately solved; then by continuing the rotation of the globe till the sun gets below the horizon, as soon as the two luminaries come into conjunction, then will the reason for the winter part of the said problem appear manifest. *

PROBLEM XXXIII.

The Reason why the Moon shines without setting, from the first to the third Quarter, to the said Inhabitants, during the Sun's Absence.

SOLUTION.

The globe continued in the latitude as above, observe while the sun remains below the horizon, every
time

*This problem is the same as problem 41, page 89, but the solution very different: that being for the terrestrial globe, shews the things as in nature, the sun being in a state of rest: this shews the thing, according to the sun's apparent motion,

time the moon makes its appearance above it, the thing sought for will evidently appear.

SECT. III.

PROBLEMS *with their SOLUTIONS relating to the inferior Planets, MERCURY and VENUS.*

PROBLEM I.

How to exhibit their several Phases according to their different Stations in their Revolutions round the Sun, as they are seen through a Telescope.

SOLUTION.

Set them to any particular given station * within the enlighten'd hemisphere, towards the sun, and it will be observed that their different phases

* These two planets are contrived, i.e. Their representatives, to screw on and off the artificial sun; and made with joints, so as to extend to any proportionable distance within their greatest elongations; one half of the surface being shaded, that which is preserved light, is the hemisphere here intended.

phases in those several stations, will be in all respects Analogous to those of our moon.

PROBLEM II.

How to demonstrate the Reason why Venus in certain Stations may rise to the Inhabitants of London within about an Hour of the same Time with the Sun in the Morning; and in the Evening of the same Day set five Hours after the Sun.

SOLUTION.

Set the sun to rise in the beginning of Aries, and Venus to her greatest elongation * in Taurus, i. e. 48 degrees from the sun, and at the same time to the extremity of her northern latitude; ** then turn about

* Elongation denotes the removal or receding of a planet from the sun, as it appears to us on the earth.

** It must be noted, that the planets do not move in the heavens exactly in the plane of the ecliptic, any more than the moon; for which reason their distance from it on either side, is call'd their latitude, which with Venus, when at its greatest, is something more than eight degrees.

about the globe till the sun rises, and observe by the index the time till Venus rises also; continue to turn the globe till the sun sets; and again inspect the index till Venus comes to the horizon, and you have the thing sought for.

PROBLEM III.

To demonstrate that to a certain Latitude, the Sun and Venus may both rise at the same Time in the Morning, and in the Evening of the same Day, Venus may set six Hours before the Sun.

SOLUTION.

Rectify the globe to the latitude of $66\frac{1}{2}$; set the sun to rise in the beginning of Aries, and observe the aforesaid directions both in rising and setting, and you have the thing sought for.

PROB-

PROBLEM IV.

To demonstrate, that to a certain Latitude, the Inhabitants may observe the Sun, Moon, Mercury, and Venus, all rising on a particular Day together in the Morning; but yet on the same Day may observe the Moon to set 12 Hours before the Sun; Mercury 14 Hours after the Moon; and Venus 6 Hours after all three.

SOLUTION.

Continue the globe rectified to the latitude aforesaid; let the moon rise near the tropic of Capricorn; the sun at the beginning of Aries; Mercury about fifteen degrees in Aries; and Venus about eighteen degrees in Taurus; with 5 or 6 degrees of north latitude, then turn the globe about, and you will find by the index the difference of time sought for.

P R O B.

PROBLEM V.

How to shew the Difference of the respective Amplitudes in the aforesaid Stations at the Time of rising.

SOLUTION.

This must be looked for on the wooden horizon; where, opposite the moon's place, it will be found almost due south, and between the sun and moon will be above 80 degrees, the sun rising nearly due east, the difference between the sun and Mercury will be found 15 degrees, and the difference between Mercury and Venus above 30 degrees, the latter rising near to north east, so that the difference of amplitude between the first and last will be near 100 degrees.

U P R O B -

• When we say (as in the solution to the last problem) let the moon rise near such or such a place, we mean only to turn the stem so as to cause the moon to rise or set in the place required, and the same thing must be observed with the sun or planet.

PROBLEM VI.

To discover the Height of the Diurnal Arc of each of the Luminaries and Planets aforesaid, on any given Day above the Horizon.

SOLUTION.

After the globe is rectified as aforesaid, screw the quadrant of altitude to the zenith of the place, and bring it to the meridian, then turn about the globe to the given day, and the degree on the quadrant, each respectively pass over, is the height of the arc sought for.

PROBLEM VII.

To demonstrate the Reason why neither Mercury nor Venus can be seen on the Meridian of London at Midnight, as all the other Planets at certain Times are.

SOLU-

SOLUTION.

Set the planets aforesaid to their greatest degree of distance from the sun when in Cancer, and you will see, by turning the globe about, the impossibility of the thing.

PROBLEM VIII.

To demonstrate, that to certain Places on the Globe, Venus may be seen at particular Times on the Meridian at Midnight, or at the same time the Sun is on the said Meridian, but below the Horizon.

SOLUTION.

Rectify the globe to the latitude of about 84 or 85 degrees, set the sun to the beginning of Aries, and Venus the same, but give the latter all the advantage of north latitude it is ever observed to have, then turn the

the globe about, and you will find that when the sun has been set above three hours, and has arrived at the meridian below the horizon, Venus will be found sparkling on the said meridian above the horizon, for the benefit of her midnight guests.

PROBLEM IX.

To represent both Mercury and Venus sometimes appearing like black Spots in the Sun's Disk, and at other times as lost behind it.

SOLUTION.

By setting them in conjunction with the sun, you have the appearance of the former, and by setting them in opposition, shews the cause of the latter.

PROB.

PROBLEM X.

*To shew the two Planets aforesaid,
as they appear in the Heavens,
representing sometimes Morning,
and at other times, Evening Stars.*

SOLUTION.

Set them, or either of them, to the east of the sun, and you will find the same rise before the sun in the morning, consequently called morning stars; but turn them to the west of the sun, and you will at once observe the reason for their appearing as evening stars.

SECT.

PROB.

SECT. IV.

PROBLEMS *on the Celestial Globe,*
with their SOLUTIONS relating to
the fixed Stars.

PROBLEM I.

To find the Latitude and Longitude
of any given Star.

SOLUTION.

Bring the solstitial colure to the
 brass meridian, there stay the globe,
 and fix the quadrant of altitude to
 $23\frac{1}{2}$ degrees, in this position bring
 the graduated edge of the said qua-
 drant to the given star, then observe
 the degree cut by the same star, for
 that is its proper latitude, and the de-
 gree of the ecliptic cut by the quadrant,
 is the star's longitude, or its distance
 from the first point of Aries.

PROB-

PROBLEM II.

*The Latitude and Longitude of any
Star being given, to find the same
on the Globe.*

SOLUTION.

Bring the solstitial colure to the meridian, and fix the quadrant of altitude to $23\frac{1}{2}$ degrees thereon, as in the last problem; lay the graduated edge thereof to the given longitude on the ecliptic, and under the given degree of latitude upon the said quadrant you will find the star sought for.

PROBLEM III.

*To find the right Ascension of any
fixed Star.*

SOLUTION.

Bring the star to the meridian;
and the number of degrees inter-
cepted

[152]

cepted between the beginning of Aries,
and that degree of the equinoctial,
which comes to the meridian at the
same time, is the right ascension. *

PROBLEM IV.

*To find the Declination of any fixed
Star on the Globe.*

SOLUTION.

Bring the star to the meridian, and
the degrees marked thereon, either
north or south of the equinoctial,
show the declination. ••

PROBLEM V.

*To find the Distance of any two Stars
in Degrees and Minutes.*

SOLU-

* For right ascension, see page 47.
•• For declination, see page 44.

SOLUTION.

If they are in the same latitude bring one up to the meridian, and observe the degree of longitude then co-inciding with it, and count the number of degrees till the other comes to the meridian likewise, and it gives the difference sought for; again, if they happen to be on the same degree of longitude, then the difference is seen by bringing both at the same time to the meridian, and counting the number of degrees between them; but if they differ both in longitude and latitude, then bring the first up to the meridian, and fix the quadrant of altitude over it, and lay it so as to cross the other, and the number of degrees engraved thereon which appears to be between both is the thing sought for.

X

PROB-

PROBLEM VI.

A Star being given, to find all those Stars which have the same Degree of Latitude with the given Star.

SOLUTION.

Bring the given star to the meridian, and note the degree it passes under, then turn the globe quite round, and observe all that pass under the same degree, for they are the stars sought for.

PROBLEM VII.

A Star being given, to find all those Stars on the Globe, which have the same Degree of Longitude.

SOLUTION.

Bring the given star to the meridian, then observe all those which are on the same meridian, for they are those sought for.

PROB-

PROBLEM VIII.

To find what Particular Stars make one continual Round above the Horizon of a given Latitude, and never set below it.

SOLUTION.

☞ Rectify the globe according to directions, problem I. page 117, then turn about the globe, and the stars which never go below the horizon are the stars sought for.

PROBLEM IX.

The Latitude given, to find all those Stars on the Globe which are never seen to the Inhabitants thereof.

SOLUTION.

☞ Proceed as before, only instead of examining those which never descend

scend so low as the horizon, you must look for those which never rise on a level with it.

PROBLEM X.

The Place and Day given, how to represent the Face and Appearance of the Heavens, and shew all the fixed Stars above the Horizon, for any particular Hour of the said Day.

SOLUTION.

☞ The globe and the index rectified as before, turn the index to the given hour, and all the whole host of the visible heavens will then be exactly exhibited by their respective representatives on the globe, whereby their several stations for that instant may be found.

PROB

PROBLEM XI.

How to find the Time of any given Star, Rising, Setting, or coming to the Meridian.

SOLUTION.

The globe first rectified, and also the hour index to 12 at mid-day, bring the given star to the east side of the horizon, and you will find the time of its rising by the said index; bringing it to the meridian will shew the time of its southing or culminating; and turning it to the west will shew you the time of its setting.

PROBLEM XII.

The Time of the Day or Night given, how to find by the Globe what Height any particular Star is above the Horizon, and on what Situation it is, with respect to the Point of the Compass, by which it may be readily found.

SOLU-

SOLUTION.

Proceed as before, then turn the globe to the given hour, and thereby you may readily perceive what stars are in or near the horizon, which are on, or near the meridian, those which are to the north, and those which are to the south, &c. and if the quadrant of altitude be laid over any particular star, it will shew its altitude, azimuth, and the point of the compass on which it is, and thus by taking the altitude of any star in the heavens by a quadrant, &c. whose representative you have upon the globe, and comparing it therewith, to see if they agree, any such star may be easily known, and the knowledge of the whole face of the heavens readily acquired.

FINIS.



THE APPENDIX.

IT may perhaps be the subject of some inquiry concerning the reason why I have not given such delineations of the respective globes we have been treating of, as might contribute to the more ready comprehending the nature of them; this I confess might reasonably have been expected, and would doubtless have been executed, had not I been certain of its being undertaken and carried into execution by a very able and skilful hand, in such an extensive manner, with respect to proper Illustrations, on a very large copper-plate, of above 600 square inches, as could by no means have been equal'd by any thing contracted to a compass fit to attend this treatise; therefore hope I shall be excused on that head, and that every one may form a proper Idea of that performance before they become purchasers thereof, I shall take the liberty to transcribe the descriptive part word for word as it stands upon the plate itself, as follows.

EXPLANATION.

The design of this plate is to represent the several uses of the new improved globes, called the patent globes, and in some measure to answer the useful end intended thereby, as may be observed by a due regard to the figures engraved thereon.

Fig. 1. represents a terrestrial globe mounted in the new method, shewing our earth so situated in its orbit, as that the north-pole is at its greatest extremity towards the sun, as at A, in the same manner as is exhibited by Fig. 4. and will produce the effects, observed by the delineation of the hemisphere, Fig. 3. where it is to be noted that the direct ray from the sun falls as it does in nature on the tropic of Cancer, in which case if the globe, represented thereby, could turn round as Fig. 1. supposes those of the new method do by the winch at top, it would describe the very circle we are speaking of, and would shew that thereby the whole

of

The APPENDIX.

of the arctic is taken into the enlightened hemisphere, while those of the antartic are excluded all benefit thereof, an emblem of which may be viewed by Fig. 3. being divided into equal portions of light and darkness, the former extended 90 degrees from the sun every way as from D. to F. taking in the whole arctic, and leaving out the antartic circle aforesaid. Let us next suppose the globe, Fig. 1. turn'd 30 times about by the winch, the north-pole will then be situated as at B. and correspond with Fig. 6. in its annual orb, and will cause the vertical ray to fall as at D. Fig. 5. being full $\frac{1}{2}$ short of the tropic of Cancer, and advances just in the same proportion toward that of Capricorn; by which the light now penetrates $\frac{1}{2}$ into the antartic circle as at G. leaving the other as at F. Let us now suppose the globe turn'd by the winch 30 times more, the north-pole will then be situated as at C. Fig. 1. and will be the same with respect to the situation in its annual orb, as Fig. 8. and will produce the effects observed by the hemisphere Fig. 7. where the vertical ray D. falls $\frac{1}{2}$ beneath the tropic of Cancer; consequently the body of the sun can be seen no farther than $\frac{1}{2}$ within the arctic circle, and extends beyond the north-pole; an equal space as at F. reaching within the same distance of the south pole, as at G. if we consider the globe as turn'd 31 times more, we shall find the north-pole situated as at D. Fig. 1. and will correspond with Fig. 10. in its annual orb, and produce the effects agreeably seen in Fig. 9. where the vertical ray falling on the equinoctial line as at D. the enlightened hemisphere extending from pole to pole as at F. and G. will to the ingenious afford a most entertaining scene, as it exhibits nature so conspicuously, shewing to the meanest capacity the true cause of the equal distribution of day and night in this situation.

From hence if the globe be turn'd about on its own axis by the winch aforesaid, the north-pole will be no longer seen above the solar horizon during the space of 6 months. At the end of the first month it will be as E. Fig. 1. and will resemble Fig. 12. in its annual course, and cause the vertical ray to fall as D. Fig. 11. and will produce the same effects to the southern inhabitants as Fig. 7. did to the northern. At the end of the second month the pole will be advanced to F. Fig. 1. and will

The APPENDIX.

will correspond with Fig. 14. causing the ray, falling direct from the sun, to appear as at D. Fig. 13. and its effects to the southern Inhabitants will now be the same as Fig. 5. produced to the northern. The third Month brings the north-pole as to G. Fig. 1. in which situation it will be directly opposite the sun, as Fig. 16. and will now produce just the contrary effects to what we observed in our first setting out, as will appear evident by comparing Fig. 15. with Fig. 3. In the former, the vertical ray D. falls on the tropic of Cancer, whereby the whole of the arctic circle was taken into the enlightened hemisphere, whereas it is here the reverse, by the vertical ray falling on the tropic of Capricorn.

In like manner, if we proceed through the remaining figures, we shall find that as all the countries from Cancer to the north-pole have hitherto gradually decreased in the length of their days, they will now increase by equal proportions, till the sun gets back again to the tropic of Cancer, as evidently appears by comparing the latter with the former figures throughout their procession; from whence also it may be noted, that all those countries between the equinoctial and the circle aforesaid, vary in the length of their days and nights in proportion to their distance from the pole, as appears from observing the latitude of any given place, and comparing figure with figure throughout the annual course.

From the center over the globe, as Fig. 1. runs a stem to which the moon hangs by a joint as at N. the body reaching parallel to the ecliptic, as at O. and over the moon is a cap which covers one half of its body, as at P. to distinguish the several phases as it passes round the earth, while the stem on which the moon hangs moves higher and lower; the moon itself is thereby made to shew its several latitudes and nodes, and by a backward motion, given to it by the wheel-work at top, shews the retrograde motion of the nodes by the inclined plane on which the moon moves, making one intire revolution in a little more then 19 of the annual revolutions of the globe.

From the pedestal on which the globe is fixed proceeds another stem, on which is placed an artificial sun, as at S. through which runs a pointer which represents a vertical ray from the sun, as at R. by which means a prodigious

The APPENDIX.

digious number of curious, useful, and entertaining problems are solved in a most instructive manner.

Fig. 2. represents the celestial globe with the sun and moon according to their apparent motions, as rising and setting, every day or every time the globe is turned about on its own axis, as at S. and M. and from the time of the moon's rising one morning, to the time she rises the next, she moves 13 degrees from the west towards the east, in such a manner as to perform the whole in 29 and $\frac{1}{2}$ days; in like manner the sun also moves so as to traverse the whole circuit in 365 days $\frac{1}{4}$, which is performed by the wheel-work at top, as at Q. To the center of the sun two jointed arms are occasionally screw'd on, to which are fixed Mercury and Venus, which by the said joints may be set to their proper stations, and thereby several entertaining problems may be solved. The dots round each hemisphere shew the different degrees of atmosphere a vertical ray from the sun passes through in the several seasons of the year, as may be view'd by the difference of D. and E. in every hemisphere.

The difference of twilight may be also observed by the shady strokes between the light and dark parts of each of the aforesaid figures.

Beyond these, are the several signs in the zodiac and days of the month engraved, and next to them the age of the moon, and the out-circle of all represents the yearly course of the moon round the sun, by which it appears to an eye from the sun, that she never moves in any part of her travel round the earth in such a manner as to appear in an orbit, whose convex side is ever towards the sun, no not even when she moves to or from her conjunctions; therefore to an eye thus placed, the periodical motion round the earth would appear as so many arches or parts of circles meeting at the feet, whose concave side is always towards the sun. By this scheme is shewn the several phases of the moon for any given day of her age, as also the nature of their several changes, &c. &c. &c. as may be observed by the solution of several problems, capable of being solved thereby as follows.

PROBLEM

THE APPENDIX.

PROBLEM I.

How to shew the nature of an eclipse of the sun.

SOLUTION.

Look for the 7th of July, over it you will see the earth's place represented by the dot, as under A. which by the moon, as at B. being between it and the sun, must in course intercept the rays of light from falling on it, as is exemplified by Fig. 21. from the moon at M.

PROBLEM II.

To shew an eclipse of the moon.

SOLUTION.

Go on to the 22d of July, and then you will see the moon, as at B, will be behind the earth at A. as may be seen by comparing it with Fig. 9. as eclipsing the moon above it.

PROBLEM III.

To shew the causes of the several phases of the moon.

SOLUTION.

The moon enjoying no light but what comes from the sun, that part of her body which is towards the sun will be always enlightened, which when it is opposite the sun respecting the earth, it appears then as a full moon, being situated so as to have all her enlightened part seen by us; but when in conjunction, none can be seen, and in a midway an equal proportion of each seen, as may be view'd by inspection in her several stations in this plate.

PROBLEM IV.

To shew the reason why the inhabitants within the polar circles are sometimes all day without night, and at other times all night and no day.

SOLUTION.

By comparing Fig. 3. with Fig. 15. the thing sought for will appear manifest.

PROBLEM V.

How to demonstrate that the inhabitants under the equinoctial line enjoy two summers and two winters every year.

SOLUTION.

Observe Fig. 3. it will be found that a vertical ray from the sun will fall, as at D. on the tropic of Cancer, and as it cannot recede any farther than that from the equinoctial line towards the north-pole, consequently it

The APPENDIX.

it will be winter to the inhabitants under that line, but when three months are over it will then fall, as at D. Fig. 9. directly on the line itself, therefore must be the height of summer, though as yet gone but half his course, wherefore at three months more it arrives, as at D. Fig. 15. which produces a second winter, and in the last three months comes back again to the line, as at D. Fig. 21. which produces the second summer, and amply solves the problem.

PROBLEM VI.

How to demonstrate that the moon is almost half a million of miles nearer the sun at sometimes than at others.

SOLUTION.

By comparing the new moon with the full moon, it will be found the difference of the distance from the sun will be no less than the diameter of the moon's orbit, which is computed at 486,600 miles.

PROBLEM VII.

How to demonstrate that the moon moves slower than the earth during her first quarter, faster than the earth in the second and third, and again slower in the last, and that the difference is equal to the diameter of the earth's orbit.

SOLUTION.

Observe the circle of the moon; at the beginning of December you will see the letters of the alphabet attending the earth and moon, each corresponding with the other for the same days, where though they set out together, those for the moon fall more and more short of the other the first quarter, get it up again on the second, gain on the third equal to that lost in the first, and at the end of the last come equal again.

PROBLEM VIII.

How to demonstrate that the inhabitants of the north-pole can never discern a full moon in summer, or a new moon in winter.

SOLUTION.

Observe Fig. 3. where the whole of the arctic circle is enlightened, it will be found, they are thereby excluded from seeing the moon, as at M. representing a full moon, and by comparing this with Fig. 15. they will seem to be excluded all benefit of the light, consequently of being able to see the moon when new, or in conjunction with the sun, as at O.

The following is an abstract of the patent granted by his majesty for these machines, the abridgement of which being applied to the poles of the ecliptic in common globes produce the surprising effects in the several improvements we have been treating of.

GEORGE R.

GEORGE the Second, by the Grace of God, of Great-Britain, France, and Ireland, King, Defender of the Faith, &c. *To all to whom these Presents shall come, Greeting.*

WHEREAS Our trusty and well-beloved JOHN NEALE, of Leadenball-Street, in Our city of London, Watchmaker, hath, by his petition, humbly represented unto Us, that he has, at a very great expence of time and money, and by long study, invented and brought to perfection, A PLANETARY MACHINE; by which the latitude of any planet, or fixed stars, may be taken; as also the uses of the ORRERY answered; which he apprehends will be of great use to the publick, as the price will be easy, the size portable, and the method adapted to the meanest capacities, not only to those who teach those noble and useful sciences, *Astronomy* and *Navigation*, by enabling them to demonstrate the truth of their arguments by experiments, but also to the heads of private families; who, by their means, will be enabled to infill into the minds of young people the true reason for all the different appearances of the heavenly bodies, and instruct them in the true principles of their motions; from whence they will be naturally led to form high and honourable conceptions and just ideas of GOD, the First Cause, on whose support the whole intire system constantly depends.

He has therefore pray'd Us, to grant unto him, his administrators, and assigns, Our Letters Patent, under Our Great Seal, for the sole use and benefit of his said new invention, and We, being willing to give encouragement to all arts and inventions which may be for the publick good, are graciously pleased to condescend to his request.

Know ye therefore, that We, of Our especial grace, certain knowledge, and mere motion, have given and granted unto the said John Neale, his executors, administrators, and assigns, Our especial licence, full power, sole privilege and authority, to make and vend the said Planetary Machine, or any part or abridgement thereof, in such manner as to him or them shall seem meet.

And to the end the said John Neale, his executors, &c. may have and enjoy the full benefit, sole use and exercise of the said invention, We do by these Presents, for Us, our heirs, and

and successors, require, and strictly command, all and every person or persons, bodies politic and corporate, and all other Our subjects, of whatsoever estate, quality, degree, name or condition they be, that neither they, nor any of them, either directly or indirectly, do make, use, or put in practice the said invention, or any part of the same, nor in any wise counterfeit, imitate, or resemble the same, nor shall make, or cause to be made, any addition thereunto, or subtraction from the same, so as thereby to pretend himself or themselves the inventor or inventors, deviser or devisors thereof, as they will answer their contempt of this Our Royal Command, and further to be answerable to the said *John Neale*, or his executors, according to law, for his or their damages, thereby occasioned.

And moreover, We do by these Presents will and command all Justices of the Peace, Mayors, Sheriffs, Bailiffs, Constables, Headboroughs, and all other Officers and Ministers whatsoever, that they or any of them do not, in any wise molest, trouble or hinder the said *John Neale*, or his executors, in or about the use or exercise of the aforesaid invention, or any thing relating thereto.

In Witness whereof, we have caused these Our Letters to be made Patent.

Witness Ourself at Westminster, the 12th day of July, in the 18th year of Our Reign.

N.B. As all the Problems on the Uses of the Globe are solved by these Improvements, in a Manner so very different from the Solutions given on common Globes, and as those who are ever so well versed in the Solutions after the old Method, must absolutely be Strangers to these: And as the Subjects of Inquiry are many of them so very striking; and at the same Time so agreeably instructive: For these Reasons the Patentee himself has been advised [*especially as he hath so much injured his own Fortune in favour of the Publick, in bringing his Plan to such a Degree of Perfection*] to persevere in the Publick Service, untill his Labours shall be crown'd with a Reward suitable to his Fatigues: He therefore, having comply'd with such Intreaties, is determined to attend any Select Company of Gentlemen or Ladies, or private Families, at any Place appointed by themselves, within the Cities of *London* and *Westminster*, or *Borough of Southwark*, from 6 to 8 in an Evening, to explain all the Particulars in the aforesaid Treatise, from Page 2 to Page 158, on the Globes themselves, in a Course of 12 Lectures, for one Guinea each Person, and for those who are already versed in the Introductory Part, and only want the Problematical Part, he will attend them thro' a regular Course of 6 Lectures, from Page 61 to Page 158, for half a Guinea each Person, or any 20 chosen Problems in one single Lecture, for half a Crown each Person. And for the Convenience of those who do not chuse to have them at their own Houses, and to whom public Houses are not agreeable, he will accommodate them in his own Dining-Room.

FINIS.



Advertisement.

THE Public are indebted to the great genius of that excellent Artist Mr. James Fergulon, for the discovery of that curious Problem Number 47. Page 102, relating to the variation of the Needle, so useful and necessary for Navigators in general; as likewise for that entertaining one No. 54 Page 106, the Solution of which unriddles one of the mysterious Paradox's in Mr. Gordon's Grammar, by proving that there really are divers Places on the Earth to which the Sun does apparently go backward and forward twice in one Day at a certain Time of the Year, without the least derogation from the miraculous going back of the Shadow as related in the Holy Scriptures..

And as in the nature of Things it is very unlikely all the uses of the Patent Globes should be already known, their Appearance on the public Stage being only in an infant State. The Patentee, therefore, does hereby request the Favour of every judicious Observer, that should any fresh Uses occur in the Course of their Enquiries thereon, that they will kindly send Intelligence thereof to him, whose Care it shall be, that an honourable Mention be made of their Service to the Public in any future Edition of this Work; or if on such Enquiries any Defect or Omissions be found in the present Performance of this Treatise, the Author will esteem himself equally obliged for such Information, in order for their Correction.

N. B. For TERRENE, p. 54, read Earthly Globe; Prob. 13, p. 124, instead of within one Hour of the same Time for every Day, read. for several Days in the year. Prob. 22, p. 131, l. 9, for 13, &c. read 12 degrees before her. In the Note in Page 86, for Sun's read, the Orbit of any Planet. And any other mistake which may have escaped notice at present, the candid reader for reasons given at the close of the preface, is desired to correct.

